DOCUMENT RESUME

ED 028 604

EF 002 632

Prefinishing of Exterior Building Components. Proceedings of a Conference of the Building Research Institute, Division of Engineering and Industrial Research (Fall 1961).

National Academy of Sciences, National Research Council, Washington, D.C.

Report No-NAS-NRC-993

Pub Date 62

Note-97p.

Available from-Building Research Institute, Division of Engineering and Industrial Research, National Academy of Sciences, National Research Council, 2101 Constitution Ave., N. W., Washington, D. C. ($6.00)

EDRS Price MF-$0.50 HC-$4.95

Descriptors-*Architectural Elements, *Building Design, *Building Materials, *Component Building Systems, Construction Industry, Economic Factors, *Finishing, Prefabrication

Current trends in architectural design and construction are described which may affect the prefinishing of exterior building components. Contents include--(1) prefinishing of ferrous metals, (2) prefinishing of nonferrous metals, (3) prefinishing of wood and composition board, (4) prefinishing of masonry concrete block, (5) prefinishing of cementitious materials, (6) economics of prefinished components in industrial construction, and (7) future trends and needed research. A bibliography of previously published Building Research Institute conference proceedings is also included. (RH)

ED028604

BUILDING
RESEARCH
INSTITUTE

PREFINISHING OF EXTERIOR BUILDING COMPONENTS

EF002632

National Academy of Sciences—
National Research Council
publication 993

1961-62

BUILDING RESEARCH INSTITUTE

Officers and Board of Governors

President - LEON CHATELAIN, JR., Chatelain, Gauger & Nolan, Architects

Vice President - PETER B. GORDON, Vice President, Wolff & Munier, Inc.

Vice President - HAROLD D. HAUF, Vice President, Design & Planning, Charles Luckman Associates

Vice President - GRAHAM J. MORGAN, President, U.S. Gypsum Company

Executive Director - MILTON C. COON, JR., Building Research Institute

PAUL R. ACHENBACH, Chief
Mechanical Systems Section
National Bureau of Standards

GLENN H. BEYER, Director,
Center for Housing & Environmental Studies
Cornell University

N. S. COLLYER, President
F. H. Sparks Company, Inc.

ROBERT W. CUTLER, Partner
Skidmore, Owings & Merrill

ALBERT G. H. DIETZ, Professor
Massachusetts Institute of Technology

JACK E. GASTON, General Manager
Building Materials Research
Armstrong Cork Company

GRAYSON GILL, President
Grayson Gill, Inc., Architects & Engineers

LEONARD G. HAEGER
Architectural Research Consultant

JOHN E. HAINES, Vice President
Minneapolis-Honeywell Regulator Company

HOWARD C. HARDY,
Consultant in Acoustics
Howard C. Hardy & Associates

JOHN M. KYLE, Chief Engineer
Port of New York Authority

ROBERT W. McKINLEY, Technical Representative,
Product Development Department
Pittsburgh Plate Glass Company

OTTO L. NELSON, Jr.
Vice President for Housing
New York Life Insurance Company

T. F. OLT, Vice President,
Research and Technology
Armco Steel Corporation

JOHN S. PARKINSON, Director,
General Research & New Business Development
Johns-Manville Corporation

DOUGLAS E. PARSONS, Chief,
Building Technology Division
National Bureau of Standards

PERRY I. PRENTICE, Editor & Publisher
House & Home

WALTER SANDERS, Chairman,
Department of Architecture
University of Michigan

D. KENNETH SARGENT, Dean,
School of Architecture
Syracuse University

R. J. SHORT, Director, Engineering Exploration
Procter & Gamble Company

EX OFFICIO:
Dr. Detlev W. Bronk, President, National Academy of Sciences-National Research Council
Dr. Augustus B. Kinzel, Chairman, NAS-NRC, Division of Engineering and Industrial Research
Harold L. Humes, Vice President, Baldwin-Ehret-Hill, Inc., Past President, BRI
C. H. Topping, Senior Architectural & Civil Consultant, E. I. du Pont de Nemours & Co., Inc., Past President, BRI

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

PREFINISHING OF EXTERIOR BUILDING COMPONENTS

Proceedings of a conference held as
part of the 1961 Fall Conferences of the
Building Research Institute
Division of Engineering and Industrial Research

Publication 993

NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCIL
Washington, D. C.

1962

The Building Research Institute gratefully acknowledges the contributions to building science made by the participants in this conference.

Milton C. Coon, Jr.
Executive Director

* * * * * * * * *

Inquiries concerning this publication, the Conference
on
Prefinishing of Exterior Building Components
or other publications from the BRI 1961 Fall Conferences, including:

Mechanical Fasteners for Wood
Design for the Nuclear Age
Performance of Plastics in Building
Identification of Colors for Building
Methods of Building Cost Analysis

May be directed to:

Building Research Institute
Division of Engineering and Industrial Research
National Academy of Sciences-National Research Council
2101 Constitution Ave., Washington 25, D. C.

* * * * * * * * *

Library of Congress Catalog Card No. 62-60081

Price $6.00

The opinions and conclusions expressed in this publication are those of the authors and not necessarily those of the Academy-Research Council units concerned.

Contents

Page

ABSTRACTS OF CONFERENCE PAPERS v

KEYNOTE ADDRESS
Thomas H. Creighton, Progressive Architecture i

PREFINISHING OF METAL SUBSTRATES

PREFINISHING OF FERROUS METALS
Raymond L. Hanson, Stran-Steel Corporation 7

PREFINISHING OF NONFERROUS METALS
James Nelson, Kaiser Aluminum and Sales Corporation 15

PANEL DISCUSSION
Moderator - S. C. Frye, Bethlehem Steel Company 25

PREFINISHING OF NONMETALLIC SUBSTRATES

PREFINISHING OF WOOD AND COMPOSITION BOARD
Don F. Laughnan, Simpson Timber Company 39

PREFINISHING OF MASONRY CONCRETE BLOCK
John A Sergovic, The Burns and Russell Company 45

PREFINISHING OF CEMENTITIOUS MATERIALS
Robert E. Parry, The Johns-Manville Research Center 53

PANEL DISCUSSION
Moderator - Martin Nosenchuk, Rayco Manufacturing Company 61

THE ECONOMICS OF PREFINISHING

ECONOMICS OF PREFINISHED COMPONENTS IN INDUSTRIAL CONSTRUCTION
John W. Baker, Butler Manufacturing Company 73

PANEL DISCUSSION
Moderator - J. W. Brock, Canadian Industries, Limited 81

CONFERENCE SUMMARY -- FUTURE TRENDS AND NEEDED RESEARCH
Luigi A. Contini, Monsanto Chemical Company 89

PREVIOUSLY PUBLISHED BRI CONFERENCE PROCEEDINGS 95

ABOUT BRI 99

1961-62
PLANNING COMMITTEE ON PAINTS AND COATINGS IN BUILDING

CHAIRMAN -- W. E. Kemp, Technical Director -- Coatings,
Tar Products Division, Koppers Co., Inc.

Joseph S. Amstock, Chief Chemist,
Eastern Division, Products
Research Co.

J. W. Brock, Technical Planning Manager,
Paints Division, Canadian
Industries, Ltd.

John W. Bruce, Jr., Market Manager,
Residential Construction, Barrett
Division, Allied Chemical Corp.

John R. Danner, Technical Services
Representative, Building Products and
Surface Coatings, Shawinigan Resins Corp.

Ray N. Elvart, President
Ray N. Elvart, Co.

Robert P. Ericson, Assistant Division
Technical Director, Paint and Brush
Division, Pittsburgh Plate Glass Co.

S. C. Frye, Application Engineer--
Coatings, Research Department,
Bethlehem Steel Co.

Bruce E. Godard, Assistant Manager--
Coatings, Product Marketing Department,
Union Carbide Plastics Co.

M. J. Horsch, Chief,
Specifications Department,
Giffels and Rosetti, Architects

George O. Lloyd, Jr., Partner,
Perry, Shaw, Hepburn and Dean,
Architects

J. S. Long,
University of Louisville

Charles E. Loucks, Technical Director,
National Paint, Varnish and Lacquer
Association

William Lukacs, Director of Research,
Buildings and Services Division,
National Council of the YMCA

Donald K. Lutes, Sr., Section Supervisor,
Precoated Strip and Industrial Groups,
The Sherwin-Williams Co.

Martin Nosenchuck, Director,
Architectural Division,
Rayco Auto Seat Covers, Inc.

Ian B. Packman, General Superintendent,
Central Maintenance Engineering
Division, Port of New York Authority

P. C. Herzog, Manager,
Trade Products Laboratory,
The Glidden Co.

Abstracts of Conference Papers

PREFINISHING OF FERROUS METALS

By Raymond L. Hanson, Stran-Steel Corp.

Changing concepts of architectural design and construction, as well as advances in chemistry, have resulted in the use of an increasing amount of ferrous metals as exterior building components. The newer organic coating systems, such as the vinyls, alkyds, acrylics, and epoxies, are discussed. Also given are descriptions of various methods of treatment of the base metal and the application of bond and finished coatings. A system of production utilizing a combination organic and inorganic sprayed-on bond coat, followed by a pure vinyl finish coat, is treated in detail. Particular attention is paid to operational problems, color and coating systems performance, and problems arising in handling the finished product. Consideration is also given to the utility of strippable coatings.

* * * * * * * * * *

PREFINISHING OF NONFERROUS METALS

By James Nelson, Kaiser Aluminum and Sales Corp.

This paper reviews the general growth of the use of prefinished aluminum and other nonferrous metals as building components. A very detailed description of the pretreatment of aluminum by using a roll coating method of paint application is presented. Types of finishes for exterior building application, such as the alkyds, vinyls, and acrylics are described. Some attention is paid to factors governing product acceptance, to the problem of product failure in the field, and to methods of recoating and repair.

* * * * * * * * * *

PREFINISHING OF WOOD AND COMPOSITION BOARD

By Don F. Laughnan, Simpson Timber Co.

The use of wood siding has been on the decline because of competition from other construction materials such as metal and masonry. Its continued acceptance requires that exterior paints and clear coatings give successful performance. Factory priming, and also complete factory prefinishing, are seen as the answers to the diminishing use of wood in construction. One system of priming, utilizing a short-oil alkyd resin, is described in detail. The advantages of factory priming are seen to be optimum conditions for the application of the primer, control of quality of the product, lower prices to the consumer, and better durability.

* * * * * * * * * *

PREFINISHING OF MASONRY CONCRETE BLOCK
By John A. Sergovic, The Burns and Russell Co.

This paper suggests that, if concrete block is to compete in the building materials market with other prefinished components, it must be structurally sound as well as attractive, and suitable shapes of block must be provided to minimize the amount of cutting and fitting that must be done by the builder. Reviews of different manufacturing processes, including various methods of producing a face by casting, spraying, and grinding, are presented. Cost comparisons of methods of manufacture of block are also made. Failures of concrete block caused by staining, cracking, etc., are discussed. Some consideration is given to repair of finish in the field, and suggestions are made about the probable future of prefinished masonry units.

* * * * * * * * * *

PREFINISHING OF CEMENTITIOUS MATERIALS
By Robert E. Parry, The Johns-Manville Research Center

Prefinished asbestos-cement materials, factory coated with organic coatings, are a relatively recent addition to the exterior building materials market, although they have a history of use in interior construction. Cementitious products now available include flat and corrugated sheets, siding and roofing shingles, low density boards, and sandwich panels. Three types of manufacturing processes are described. These are the press process, the Hatschek or wet process, and the dry process. Various methods of curing are considered, as are costs, durability, and field problems.

* * * * * * * * * *

ECONOMICS OF PREFINISHED COMPONENTS IN INDUSTRIAL CONSTRUCTION
By John W. Baker, Butler Manufacturing Co.

Recent advances in factory prefinishing of building components have resulted in long-term savings in maintenance costs. This paper is a survey of current practices, materials, and methods including the costs of factory finished metals and masonry products as they are used in the construction of industrial buildings. A detailed comparison is made of the costs of shop and field applied coatings of such components. The durability and life expectancy of several coatings are considered, and there is a detailed breakdown of labor and material prices involved for sidings, walls, several roof systems, and other related items.

* * * * * * * * * *

FUTURE TRENDS AND NEEDED RESEARCH
By Luigi A. Contini, Monsanto Chemical Co.

This paper reviews the traditional function of exterior building walls. It is forecast that walls of the future will continue to perform the traditional functions, but that others, such as heating, cooling, and lighting can be expected to be added. No radical innovations, though, can be expected in the near future. Continuing research must be conducted by the coatings manufacturer, component manufacturer, contractor and builder, and the architect. The greatest need is for communication, cooperation and understanding among these groups.

Keynote Address

By Thomas H. Creighton,* Editor,
Progressive Architecture

The purpose of this paper is to describe trends in architectural design and construction which may affect the prefinishing of exterior building components. The job of describing present trends in architecture, for any purpose, is not an easy one. Which trend do we want described — there are scores of them! This is a period of individual expression and the investigation of many forms and techniques. In a symposium which Progressive Architecture published in the spring of 1961 about a hundred of the architects who seem most influential at the present time almost unanimously described the current situation as one of "chaos in design." This seems to be true, when you juxtapose, as noteworthy buildings of recent years, the sculptural, brute-concrete designs of Le Corbusier; the suave, presumably industrialized designs of Mies van der Rohe; the occasional romanticism of the late Eero Saarinen; the discipline in steel on which people like Soriano and Elwood insist; and the freedom in concrete that people like Kahn and Pei expound; the hyperbolic curved surface and the New Sensualism, with the New Classicism, and the New Brutalism crowded between. A round-trip on the circuit of the new air terminals at Idlewild International Airport is the only demonstration one really needs of this period of chaos.

How can a researcher, a producer, or an industry group, draw any conclusions from this picture of architecture in 1961? To try to do so, it is first necessary to understand why the present situation exists. What has happened is basically very simple. In the early part of the century a revolution in architectural design and the technology of construction, which had been brewing for some time, reached a degree of success, and changed the whole approach to architecture.

To oversimplify, the nature of this revolution was a discarding of the imitation of past techniques and formalistic methods of planning; and it was the introduction of two principles:

1) That buildings should be planned primarily to satisfy their functional purposes.
2) That architecture should make use of the materials and techniques of the industrial revolution and the machine age.

---

*CREIGHTON, THOMAS H., Consulting Editor, Reinhold Publishing Co. Book Division; graduate of Harvard University and Beaux Arts Institute of Design; Fellow, AIA; Member, American Institute of Decorators, American Hospital Association.

It seemed to be a recognition of the time in which we were living. Its result is the direct, simple building without superficial ornament, apparently making use of a large number of prefabricated components, depending on subtlety and refinement of proportions and scale and relationship to its surroundings for the distinction between good and bad examples. Its apogee is the Seagram Building. Its lowest points are the inept imitations that we see on every hand.

In the case of any revolution, there is a reaction, a counter-revolution. It is now taking many forms. First, there is a reaction against what is considered slickness: the too perfect, impersonal construction that machine technology makes possible. Second, there is the opposite reaction: the feeling that we have not yet developed the machine output, that buildings are still largely put up by hand, unit on unit. Then, there is a reaction against flatness of surface, and the desire to gain plasticity, sculptural form, or at the least a broken, irregular facade. Finally, there is a reaction against monotony and sameness, which calls for textures, colors, even ornament and a greater use of applied art.

The result at the moment, as previously stated, seems to be chaos. We have seen that the various aspects of the counter-revolution are inconsistent among themselves. The architects point out that society itself is in a state of unrest amounting to chaos, and since architecture characteristically represents its society, it is reasonable that its present expression is a confused one. And then, with what we have come to call the exploding technology of today, there is the feeling that we must continue to experiment, and not run the risk of jelling an architectural expression, of freezing a technology, or of arriving at the next style too soon.

What are the implications, then, of such an industrialized process as we are gathered here to discuss: the prefinishing of components? We could be pessimistic and say that we are in a sorry state -- no industry can develop in a state of confusion.

But I think we have to dig a little deeper than that, and if we do we come up with a more optimistic picture of the segment of the construction industry whose present development and future possibilities we are discussing. One thread runs through all this background. It is the constant, consistent concern with industrialization. Architects may be afraid of it; they may even rebel against it; they may feel that not enough use has been made of factory-produced products, or they may feel that these products have not been well used, but no one thinks of denying the impact of industrialization on architecture, or the need for studying more carefully its proper use in the design and construction of buildings.

The reason the picture is optimistic for such basic industrial processes as prefinishing of components is that this study of the proper use of our technology is just now becoming a serious and a comprehensive one. The historical period that I have reviewed so quickly was a time of emotional adherence to a vague concept known as "the machine." Very few of the early masters really understood anything of industrial processes. Few of them were truly interested in research. George Nelson commented in our symposium: ". . .the architect is perhaps the last professional type in our society to realize that mass production is a fact." But the point is that he is now realizing it. I think that every architect today agrees with Walter Gropius when he says: "Very gradually the process of building is splitting up into shop production of building parts on the one hand, and site assembly of such parts on the other."

There are several reasons for the rising need to understand and use, and perhaps control, the technology of prefabricating and prefinishing. In the first place, within the present chaos of design the profession realizes that there must be some discipline, or things will get completely out of hand. That discipline, basically, is the application of factory manufacturing and finishing processes, modular assembly, and what Robert Geddes in our symposium called ". . . the fundamental idea, the dynamic force, in our society — industrialization."

So, the very confusion of the present situation seems to demand one consistency, that of understanding and use of preproduced units. Secondly, there is a demand for economy; there is so much that needs to be built, and the future demands will be so staggering, that unit building costs must be watched with ever greater care. Although industrial production and finishing methods have not always resulted in comparative economy, we know that in thelong run, assembly of prefinished parts must prove more economical that the on-site building and finishing methods that have been traditional. Finally, there is a strong trend in architectural practice today toward the larger planning problem — the urban redevelopment, the group housing, the college campus, the civic center, even the new town. And as Victor Gruen says: "The problems of solving the organization of individual facilities into groups of such facilities becomes increasingly urgent . . . and the needs for fast and inexpensive construction . . . force us into mass production and prefabrication methods."

If we accept the premise that relationships between the architects and those who produce industrially finished components have not been of the best, and if we proceed from the assumption that today we have, among the active architects, a group of materials-oriented, research-minded, technologically-interested designers, then how can we best work with and in the interests of these people? I think that two things should be kept in mind.

One, we have to face the fact that an important part of the present counter-revolution is a desire for enrichment of our architecture, and a revolt against repetitive monotony. This implies, to put it simply, a range of choices in colors, textures and types of finishes which give the greatest possible play to the creative imagination and the widest possible range of esthetic choice.

Second, we must also face the fact that the architect himself wants to have a say in the development of the materials that he is going to use. This is particularly true, I think, in the realm of finishes. There have been several instances in recent years of lack of acceptance of prefinished materials by the architectural profession. Any good critic, anyone thoroughly familiar with current trends, desires, or even prejudices in the architectural design groups, could have predicted those esthetic failures. They were failures because of bad choice of color or texture. Potential failures for technical reasons: lack of applicability, lack of durability, or other reasons, are just as important. The architect is a detail-minded designer, and he is the agent of his client and the guardian of his client's investment. For these reasons it would seem advisable to consult "the architect" as a professional group; not only to furnish him with products, but to make sure that the product being furnished is what he needs. As Minoru Yamasaki has said: "I think it is up to us to use our industrial processes in such a way as to attain the type of architecture to which we aspire. Consequently, I think the architect-designer should be very much involved in the product and production methods and should be familiar with the industrial processes which, to a measure, control and affect the design of our buildings."

To summarize, in viewing the architectural scene at this time, it seems that the apparent confusion and diversity of design is not cause for alarm on the part of those concerned with the prefinishing of exterior component parts of buildings. It is a reaction against the superficialities of the earlier periods of the movement, and not against the basic principles. It is, in fact, a move toward deeper understanding and use of the underlying principle that the early heroes of that movement fought for; that of making architecture an expression of the industrial production methods that identify our time. We are dealing now with a desire for greater enrichment, and that is the obvious underlying purpose of prefinishing. And we are dealing now with a group of architects who are concerned with building many buildings, building them well but inexpensively, and building them as much as possible with industrially produced and finished components. Finally, we are dealing with people who want to "get into the act." They have strong convictions and strong feelings. They are constantly writing more specific and more knowledgeable specifications. They are interested in research, on their own part and on the part of others, and they want to have some hand in the development of the components which they are going to design into their buildings, recommend to their clients, and specify in their contract documents. I feel, however, that whatever superficialities, difficulties, or inadequacies there have been in the relationship of architectural development and the production of fully finished components for the architects to specify, can be eliminated by conferences such as this one, devoted to a serious study of the needs, the possibilities, and the future of this trend in the building industry.

PREFINISHING OF METAL SUBSTRATES

Session Chairman — Bruce E. Godard
Assistant Manager — Coatings
Product Marketing Department
Union Carbide Plastics Company

Prefinishing of Ferrous Metals

By Raymond L. Hanson,* Chief Engineer,
Architectural Products, Stran-Steel Corporation

INTRODUCTION

Exterior building components of ferrous metals have been used in modern building construction for quite some time, and we may agree that there is nothing particularly new, per se, in the prefinishing of some of these components. Steel panels, prefinished with porcelain enamel for architectural appeal and weathering ability, have been in use for at least 50 years. Low carbon steel sheets prefinished with a coating of zinc for corrosion protection have been used an even longer period of time. In this same category, we might also include roofing panels prefinished with a protective coat of bitumastic material.

Aside from porcelainizing and galvanizing, there has been very limited use of completely prefinished ferrous metal exterior building components. Prefinishing, as we have come to define the term these days, is the factory application of those materials which are expected to impart corrosion protection, color, surface texture, or other qualities to the component. Prefinished products are those which, when set in place and secured, become an integral part of the entire construction and which need no further handling, painting or finishing of any kind.

Recent trends in architectural design and construction, and the tremendous strides made by the chemical industry in the relatively recent past, have changed the picture from one of relatively limited use of prefinished components to one of very broad application. Trying to decide which came first, the trend or the prefinishing, is a little like trying to decide about the proverbial chicken and the egg, but prefinishing is a fact, and those who wish to maintain a progressive attitude must recognize this fact and act accordingly. Coatings designed for protection and to provide other qualities have experienced a marked advance in the last few years, and will be our principal topic of discussion.

Our company's entry into this field has been quite logical. One of our principal divisions of operation has been the manufacture and sale of prefabricated and pre-engineered metal buildings. The Quonset hut was our first successful product and what might be called the forerunner of the metal building industry. Exterior cladding on the Quonset building was standard, corrugated, galvanized sheet metal. A logical improvement, along with the change to a more modern, rigid-frame, low profile building, was the addition of color to the exterior building cladding to give greater architectural appeal and to reach a broader sales market.

---

*HANSON, RAYMOND L., B.S. in Civil Engineering, University of Michigan; Member, Missouri Society of Professional Engineers.

Our first attempts were directed only at providing a colored coating directly on the galvanized surface of the ribbed sheets which we use as cladding on our standard buildings, with no particular thought or emphasis given to the additional protection of the base metal which this coating might afford. This was a pioneering effort on our part since such a product was not available in the metal buildings industry.

To our surprise, sales acceptance was very good, and the effect on our business was manyfold. Experimental, makeshift equipment was put temporarily into 24 hour-a-day service, week in and week out, to fill the orders which came in for our standard buildings with color coated, ribbed steel panels.

As could have been expected, some of the first customers asked, in addition to the colors which were provided, what supplementary protection this organic film afforded the galvanized sheet. Such questions became more numerous, and it became evident that to continue in this field would require the development of a protective film which would provide color as well.

COATING SYSTEMS

A large majority of organic coatings used for the protection of exterior ferrous metal building components today can be found in the list below:

1) Pure vinyl
2) Vinyl modified alkyd
3) Melamine modified alkyd
4) Acrylic
5) Epoxy and modified epoxy

Each of these systems should be applied over a bond or primer coat. This is the initial portion of the coating system applied to the ferrous surface. In certain instances, depending upon the anticipated handling methods and ultimate use of the product, the system, including the primer, may or may not be applied to a galvanized surface. The galvanizing could then be considered part of the total prefinishing system for a ferrous metal component.

Each of these systems in common use has a field of technology behind its development which is too wide for complete discussion here. However, some of the principal features of each can be discussed.

Treatment of Base Material

Preparation of the basic ferrous stock for receiving the coating system varies from a complete pickling or cleaning operation, in the case of bare steel, to no treatment at all in the case of galvanized steel.

Bond Coating

The bond coat or primer coat in any of these common systems must perform two important functions. First, it must have an inherent ability to adhere tenaciously to the base material, be it bare steel or galvanized. Second, and of equal importance, the bond coat must present a surface to which the finish coat will adhere adequately.

There are two basic systems by which both of these functions can be accomplished. The first is a five-stage phosphate treatment. This method requires a sizeable installation of equipment, continuous operator control, and requires that the final coats of the protective coating system be given without undue delay. The other method is one of applying to the base material a mixture of organic and inorganic compounds, including a phosphate/chromate complex which reacts chemically with the surface and deposits a film, and a vinyl fortified with zinc chromate to stabilize the resultant film and provide the necessary surface for application of the final coats. This latter method results in a much more stable bond coat allowing for substantial delays, if necessary, prior to finish coat application. In most instances, this has proved a much more practical and economical type of bond coating than the five-stage phosphatizing.

Finish Coats

Each of the common organic coatings referred to previously has certain properties which render it particularly advantageous for a certain type of application. Each also has certain relative disadvantages which must be considered, not only in the method of application, but also in the anticipated end use of the coated product. The vinyl alkyds, for example, are somewhat sensitive to alkali attack. They will mildew, and they require a relatively longer bake-out period for complete curing. The epoxies, while presenting a very fine weathering surface, have a tendency to lose gloss quicker than some of the others. Currently the epoxies are relatively high-cost materials, and require either a very high bake temperature or an extended baking time, because of their thermosetting properties.

Acrylics have excellent gloss and color retention properties, although they are less flexible and, therefore, more subject to chipping than some of the other coatings. They can be modified to provide flexibility, but if this modification is made they lose some of their hardness. Melamine alkyds must be relatively thick to provide comparable performance as protective coatings and they are also subject to rapid loss of gloss and to embrittlement on aging. Pure vinyls, in which category our company's coating falls, can be cured rapidly, and if properly pigmented, will have good resistance to both acid and alkaline exposure. By properly plasticizing and stabilizing, these coatings provide good resistance to ultraviolet rays. They also have very good wearing qualities at relatively low film weights, and are available at reasonable cost.

These systems of finish coatings can be applied to the bond coated material by three different methods: spraying one side in a horizontal position, spraying one or both sides in a vertical position, and flow coating or curtain coating.

Spray coating or curtain coating on one side in a horizontal position requires the simplest arrangement of conveyors and ovens. It is restrictive, however, in that thermoplastic coatings become very difficult to handle, if it should be desired to coat the reverse side of the panel or component. The finished film on the underside of the panel softens again as it travels through the ovens and is therefore easily marred by the conveyor itself. Thermosetting films are not subject to this hazard.

Curtain coating, which is a method of moving the component past a solid curtain of paint, probably has its greatest advantage in the saving of paint. There is no waste since any paint which falls past the edges of the component is collected and recirculated to the system. Spray coating obviously wastes a substantial amount of paint by overspray and by its being drawn off by the ventilating system.

One very important feature of the finish coat application procedure which has been found to have a definite effect on the quality of the coating is the flow-out time -- the elapsed time between the application of the film, whether it be by spray or curtain coating methods, and the entry of the component into the curing ovens. Sufficient time must be allowed before baking for the paint to attain a completely integrated film, and to eliminate any areas of weakness that may be subject to corrosion deterioration.

In view of the demand for protection as well as color in the organic coating on our ribbed sheets, we investigated all the above types of coatings and decided that, for the particular end-use of our product, the combination organic and inorganic sprayed-on bond coat followed by a pure vinyl finish coat would be the best system to adopt. Figures 1 - 6 illustrate some of the processes and equipment involved in the production of our color coated ribbed sheets.

OPERATIONAL PROBLEMS

The initial operation of our completed line was accompanied by the usual number of technical difficulties which were eliminated in due course. There were two principal problems, however, which deserve comment. The bond coating material was clear, and of the prereacted type which, when applied to the panels, resulted in a colorless bond coat film. We found it very difficult to locate areas which the bond coating had not reached, as a result of improper action of any of the nozzles, because the coated surface could not be visually distinguished from the uncoated surface. Our suppliers did an excellent job of providing us with a slightly pigmented bond coat so that these areas could be easily perceived by visual inspection.

It was also found that temperature and humidity conditions had a significant effect on the process. The changes in these conditions, which would occur within a period of one working shift, were serious enough to require several changes in the ratio of paint to thinner for proper application of the mixture. Before these changes were made, we either found the film too wet for adequate curing and drying or, the paint would partially dry in the spray between the nozzle and the panel, resulting in an unsatisfactory appearance. We experienced the greatest amount of trouble with those colors which had an aluminum flake pigmentation designed to give the finished product a metallic sheen. The problem was considered serious enough so that we ultimately eliminated this metallic pigmentation from all colors.

COLORS AND COATING SYSTEM PERFORMANCE

Our standard line of colors includes eight shades of basic blues, greens and grays, and

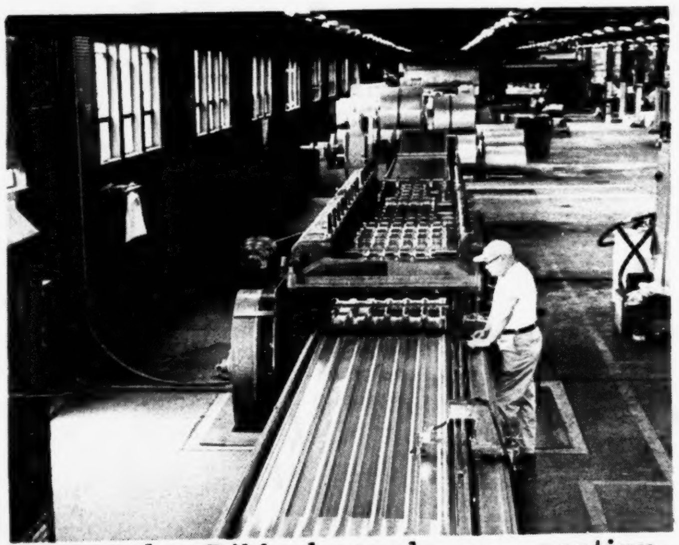


Figure 1. Ribbed panels are continuously roll formed from 10-ton galvanized steel coils.

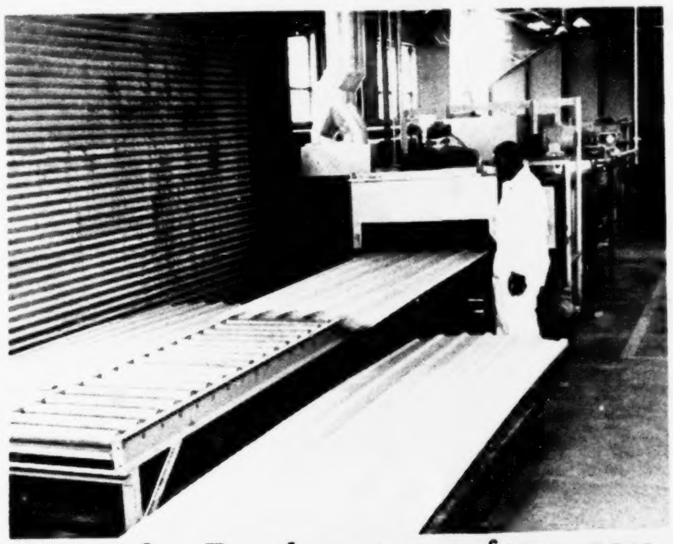


Figure 2. Panels emerge from combination infrared and gas convection heated oven after being bond coated in booth in background.

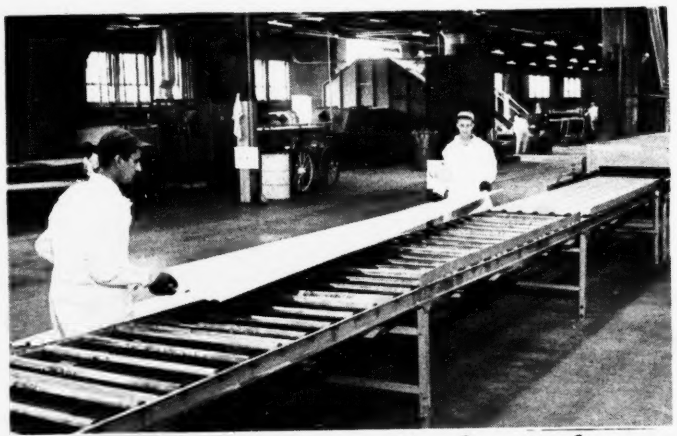


Figure 3. Bond coated panels are conveyed by motorized roller to a preheater and brought to uniform temperature before coating.

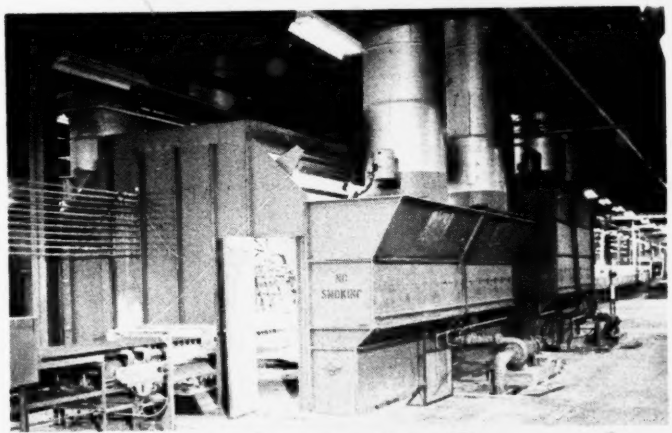


Figure 4. In 2 spray booths on color-coating line 3 separate coats are applied; 2 by stationary nozzles, and final coat by rotary equipment.

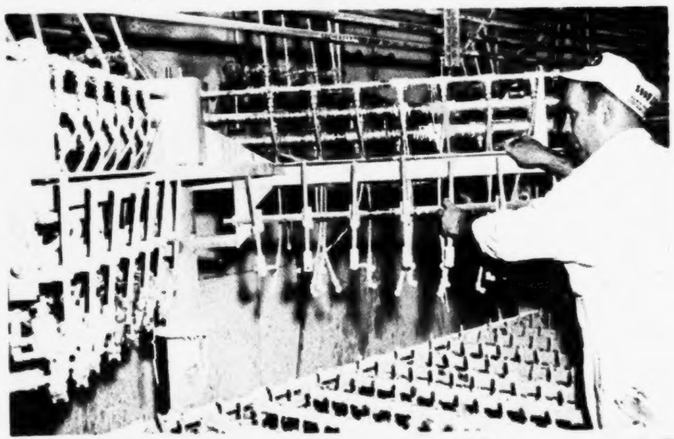


Figure 5. Operator shifts set of 7 guns out of spraying position for quick color change on production line.

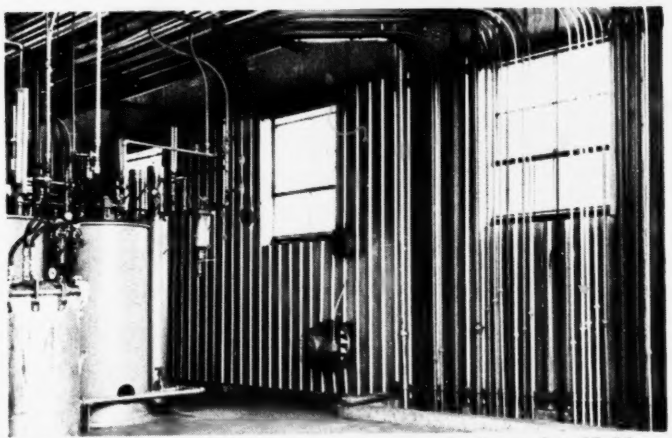


Figure 6. Separate mixing building holds elaborate piping for carrying standard colors, bond coat and thinners to points of application.

three accent colors: white, orange and yellow. They were selected for their compatibility and for their architectural appeal for the type of application to which our standard line of buildings is best adapted.

We have established a performance specification for the coating which assures a quality product. It was felt that the performance type of specification was most adaptable to our needs. Specifying the basic system and the requirements of end-product quality put the burden of system formulation on our suppliers who are experts in their fields.

Perhaps the most rigorous tests which sample panels must undergo are artificial weathering tests. These include salt spray, weatherometer, humidity, and water immersion tests. The sample panels are required to exhibit virtually no deterioration as a result of these exposures, and a complete program of tests has proved that the coating system will perform under these conditions. Additional requirements of our performance specification include such items as adhesion, color and appearance, blocking, flexibility, abrasion resistance and impact resistance.

The opinion has been expressed many times that an unsightly coating job is worse than no coating at all. Adhesion of the vinyl film to the base material is of utmost importance in order to prevent peeling or separation of the film from the substrate upon field exposure. Proper formulation of the bond coat, so as to obtain adequate adhesion, is the answer. Our performance specification sets forth a test which involves scoring the film and attempting to peel it back from the substrate. There is no precise adhesion test for films of this thickness either in ASTM or Federal Specifications, and this manner of testing has proved satisfactory for our purposes. In this test we feel that the coating system should pull apart before it can be peeled from the surface of the substrate. If it can actually be peeled the adhesion is not adequate.

Color matching and appearance are of great importance, especially in a situation where additions may be made to the building at a later date. It is imperative that the finish, appearance, and color match of the exterior components of a building addition shall be as nearly identical as possible to those of the original building. To this end, we match all shipments of coating materials to an established standard, and maintain a close inspection of our prefinishing operation so that uniformity is maintained from day to day and month to month.

Blocking, or the sticking of the film on the finished surface of one component to the back of another component in contact with it, is important in stocking, packaging, shipping and field handling operations. It is imperative that the prefinished component have the inherent ability to withstand detrimental blocking. Film hardness, complete cure, and cooling in the finishing operation prior to stacking and packaging are the principal factors which lend this property to the film. This item is the primary reason for the extreme length of the baking and cooling run-off conveyors of our production line.

All of our components are preformed prior to finishing with the vinyl color coating. Panels are roll formed, flashings are brake formed and our special window is a deep drawn item. They are coated after forming for two reasons: first, no special reworking of forming tools was necessary to accomodate the coating system, and second, this eliminated any possibility of zinc flaking and subsequent film failure.

We have included in our performance specification, however, a requirement that the film be able to withstand a 180° bend test with neither loss of adhesion nor the development of cracks in the coating. This, we feel, is necessary to allow the field forming of certain components from flat stock, or the reworking of some of the flashings of our buildings as may be necessary.

In our specification, we have arbitrarily set a wear index for testing the resistance of the coating to abrasion. This is of particular importance in the handling operation, both at the factory and at the field site. After all, these prefinished components are ultimately installed by the building trades and they must be able to withstand a certain amount of rough handling. From a practical viewpoint, we have found the system very resistant to abrasions other than scratches of sharp pointed objects, such as the edge of one sheet being slid across the finished surface of another sheet under it. Workmen walking on the sheets in the course of installing them on roofs have caused no detrimental effects, especially if the workmen wear crepe soles. In addition to abrasion resistance, we have arbitrarily set a requirement of impact resistance of the finished coating. This assures ourselves and our customers that, even though the components may be dented or similarly damaged in installation or in-place use, there will be no detrimental effect on the film integrity, the protection of the sheet, or its appearance. Our test requires that there be no peeling, no loss of adhesion, and no cracking of the film under a prescribed amount of impact energy. The requirements of our specification all have a very logical grounding in practical requirements of handling, packaging, shipping installation and, of course, end-use exposure to the elements.

It is recognized that these tests are all artificial means of producing conditions similar to actual exposure and handling, and that they do not indicate the actual length of permanent service which might be expected. There is, however, a history of very satisfactory performance of a coating similar to this system which has been in actual service in a steel mill atmosphere for approximately 10 years. We expect our system will perform equally well.

It should be pointed out that, while this is our own particular system, selected for our own purposes, there are many products and coatings of this type available which can be used for a great number of exterior building component applications. Industrial curtain wall panels with various coatings in a great range of colors are available from several manufacturers. Completely prefinished cooling towers and fan housings are on the market which require no field work other than merely setting them in place. Prefinished doors and windows are available. In fact, nearly any exterior building component can be obtained with color, protection, and economy built right into it by the manufacturer.

Normally these components are installed in a very practical manner, either with sheet metal screws, blind rivets or some kind of clip system, and depending upon the degree of architectural acceptability which must be provided, these fasteners can be prefinished to match the basic component or to accent it in color. The obvious benefits to be derived are freedom of design and color use for the architect, economy of installation by the elimination of on-the-job painting, and the equally important feature of having a baked-on coating applied under factory controlled conditions. Such a coating will provide much longer service than any field-applied system. The cost of providing these prefinished components is obviously more than the cost of unfinished components. However, where the end-product is to have some type of protection or color applied as part of the total construction project, the use of prefinished components can still frequently provide economies both in the initial installation and in cost of maintenance.

We have found in our own system that the difference in relative cost between the factory-coated sheets and the field application of a comparative coating or paint system places the prefinishing method in a very advantageous position. In many instances this system will run as little as 1/5 the cost of field painting. All of these are attributes which make the prefinished component attractive to the builder, to the designer and ultimately, of course, to the owner.

FIELD EXPERIENCE

One of the greatest problems encountered in assuring the integrity of any protective film after erection is that of educating the dealers and their erection crews in methods of handling the components. Crews long experienced in rough handling of comparatively damage-proof galvanized sheet metal or prime coated steel have to be taught a respect for the high quality of the protective coatings in order to prevent scratches, abrasions, and gouges.

In most instances slight abrasions and scratches can be easily touched up in the field by spraying the surface with the proper mixture of thinner and color coat, which is usually sent along on each job. Such minor repairs have been facilitated by the development of a pressurized spray can. These are particularly adaptable to the color coating of miscellaneous flashings which may be applied to the building as part of a special window or door treatment. If the coating system is thermosetting, strippable plastic films can be applied for protection during handling and erection operations. This assures a clean, bright and smudge-free appearance which is important to both architect and owner, and also to the erector, because it saves the time and money usually spent on clean-up operations.

Prefinishing of Nonferrous Metals

By J. S. Nelson, Paint Line Superintendant,
Kaiser Aluminum & Chemical Corporation

For many years, the use of prefinished nonferrous metals for building components has been a common practice, but not until the late 1940's and early 1950's did nonferrous prefinishing receive the major acceleration that has propelled it to the point where today it ranks as one of the nation's most rapidly expanding growth areas in the construction field.

The first significant nonferrous applications were in aluminum awning and residential siding applications, and these markets still constitute the major portion of prefinished production. The phenomenal and continuing growth of the use of this type of material in various construction applications is due to lower labor and material costs, and to the handling savings inherent in its use.

The primary application techniques for prefinishing are conventional air, airless, or electrostatic spray, flow coating, dip, and roller coating. All of these techniques are in common use following the cleaning and prepaint treatment of the aluminum substrate. However, this presentation will be limited exclusively to the roll coating technique of application and its characteristics.

Current indications are that 1961 production of prefinished aluminum will be 300% larger than it was in 1957, and forecasts for 1964 predict an increase amounting to 200% over 1961 production. The vast majority of actual field experience and field exposure has been in residential or mobile home applications. This has provided a wealth of information and experience spanning 15 years that will be invaluable in the next few years as this product receives an ever-increasing share of the industrial and monumental types of applications.

EQUIPMENT AND CONTROLS

The roll coating method of application has gained wide use in the field of pre-enameled aluminum production. The method consists of a series of several separate operations that process the material through a prepaint treatment, paint application and final bake. The entry equipment consists of a two-coil payoff device, an entry feed, bridle, a shear, splicing equipment, and an entry accumulator, as shown in Figures 1 and 2. These five pieces of equipment permit a rapid coil change without necessitating a stop in the surface preparation, painting, baking, or rewinding of the finished coil.

A two-coil payoff device permits one coil to be processed while a second coil is mounted

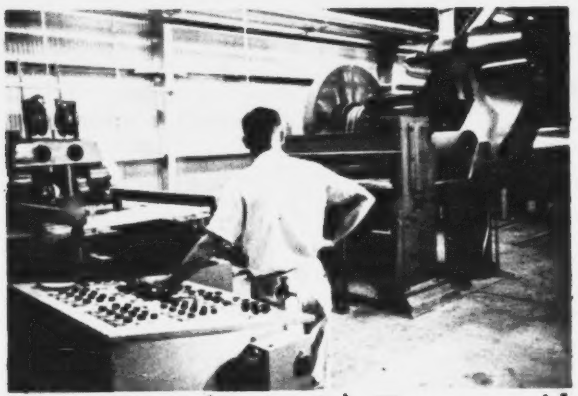


Figure 1. (R to L) Two-coil turret payoff reel and coil cart; entry feed; bridle; tail shear; coil splicing equipment.

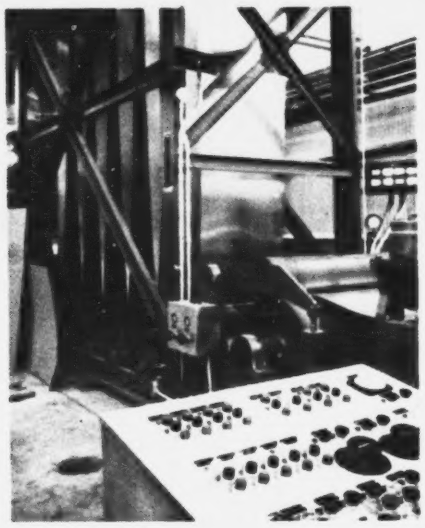


Figure 2. Entry drive bridle and metal accumulator in the loaded position.

and in the ready position. Since the nature of the total operation is continuous, it is imperative that the entry and exit terminal equipment be designed so that rapid coil change is possible without any change in the pretreating, painting, or baking portions of operation.

The entry feed bridle is used to feed the leading end of the new coil into the splicing and drive equipment. The entry shear is used to cut scrap and square the ends of the coil as they are started and depleted. The splicing equipment, in this instance, is a double-headed metal stapler which traverses the width of the coil web, intermittently placing the staples at a predetermined frequency.

The entry accumulator is composed of two sets of rolls. The set at the lower position is fixed, while the set in the upper position is designed to permit travel either up or down. During normal operation, the moveable carriage remains in the upper or loaded position. This permits the storage of approximately 150' of strip. As the end of the coil approaches, a drive bridle at the entry of the accumulator is stopped, permitting the shearing and splicing of the new coil into the process. During this period the remainder of the line equipment continues to operate, drawing coil from the storage by lowering the upper roll carriage. At the completion of the splice, the bridle will overspeed, reloading the storage space in the accumulator; 60 to 90 seconds of storage time are available.

The second phase of production concerns metal preparation. The equipment needed for this operation is shown in Figures 3 and 4. There are five stages in this process. They are:

1) A hot spray degrease
2) A warm water rinse
3) A warm spray chromate conversion coating
4) A cold spray water rinse
5) A warm spray dilute chromic acid rinse

By metered additions to Stages 1, 3 and 5, determined by hourly chemical analysis, a uniform, well controlled pretreatment for the organic coating is applied. The coating provides a firm adherent base and improved service characteristics of the base metal and paint system.

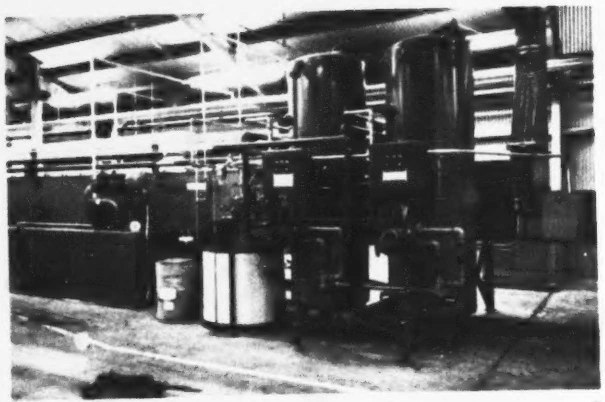


Figure 3. Hot spray degrease and tanks for metal preparation.

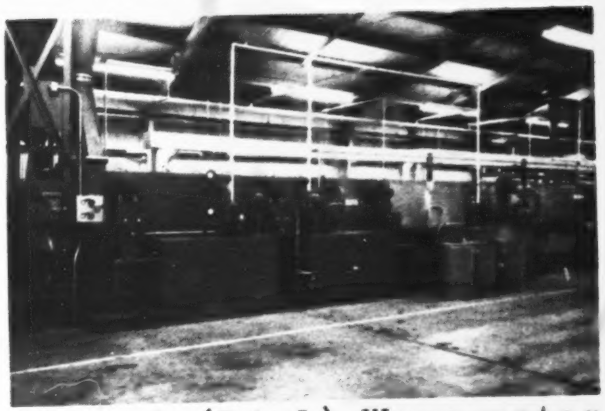
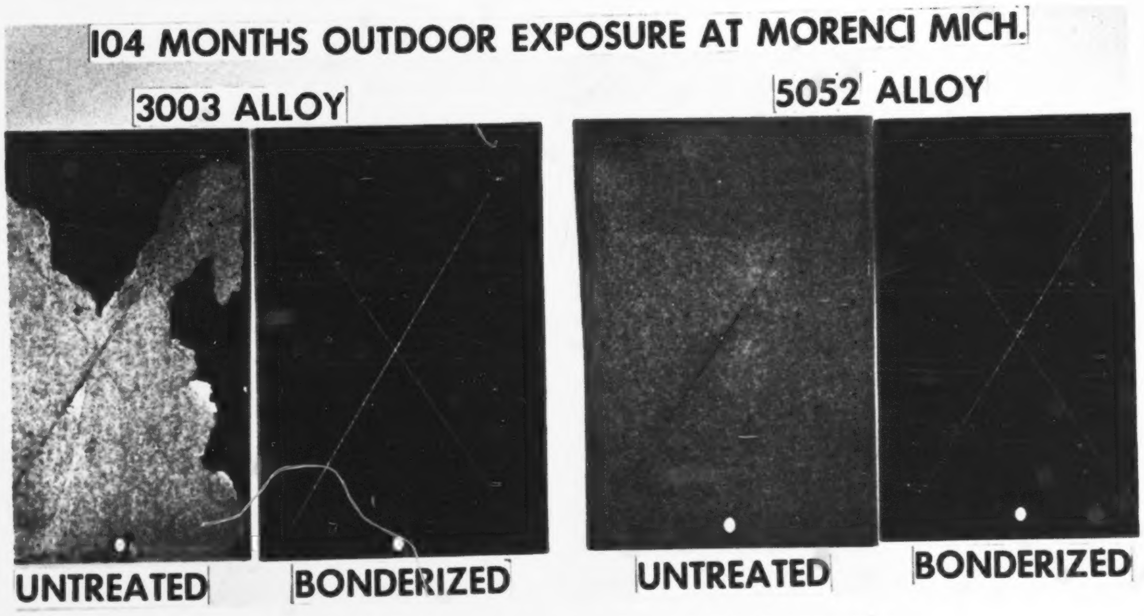


Figure 4. (R to L) Warm water rinse tank; warm chromic acid spray tank; cold water rinse tank; warm dilute acid rinse.



104 MONTHS OUTDOOR EXPOSURE AT MORENCI MICH.
3003 ALLOY
5052 ALLOY
UNTREATED
BONDERIZED
UNTREATED
BONDERIZED

Figure 5. Condition of treated and untreated panels.

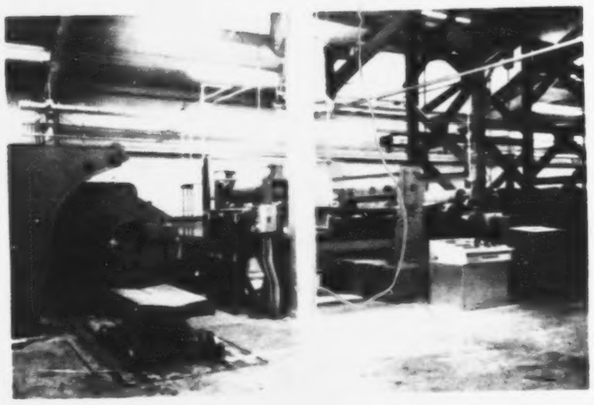


Figure 6. (R to L) Exit accumulator in unload position; exit tail shear; tracking roll; rewind reel and belt wrapper.

The first stage of the aluminum pretreatment is a metal wash, or degreasing cycle. This wash utilizes a mild alkaline cleaner heated to approximately 170° F and applied through multiple spray headers on both sides of the web. The cleaner is generally designed to provide a water breakfree surface and may etch very lightly, but not to such a degree that smut is developed. Squeegee rolls at the exit of the tank remove the cleaner and permit it to drain back into the pump and heating chamber.

It is recommended that hourly analysis of the cleaner be made in order to maintain a uniform concentration. Adequate and controlled degreasing is essential to the success of the final product. Cleaning cycles of 20 - 30 seconds are generally acceptable since the mill lubricants and soil on the aluminum are light bodied and quite easily removed.

The second stage of the metal preparation unit consists of a hot water (130° F) spray rinse for a duration of approximately five seconds. At the termination of this cycle, the web is again squeegeed to prevent carryover into the third stage, in which a warm (100° F) spray treatment produces a chromate conversion coating. The spray cycle is approximately 20 seconds and the concentration, purity and spray volume of the solution are maintained at such a level that 25 to 35 mgs. per sq. ft. of coating is applied.

Concentration of the bath is maintained by a metered, continuous addition of the chemical solution at a predetermined rate. A controlled amount of impurity is desired in the solution. Two systems can be used to control impurities. One method is to establish a controlled overflow of the solution with the addition of a corresponding amount of fresh water. Another technique is to process a metered proportion of the bath continuously through ion exchange towers. The ion exchange units remove impurities at a predetermined rate. This prevents the formation of sludge or waste deposits that would accumulate in the holding tank or spray header system.

The rates of solution make-up are determined by electronic controls, or by reference to tables that calculate the consumption rate of the chemicals based on the sq. ft. of surface treated in a base period. In all cases, it is desirable that the additions and impurity control be regulated on a continuous basis to prevent erratic changes in the nature of the solution.

Following the chromate conversion coating, a cold water spray rinse of approximately five seconds' duration removes the excess solution that was not wiped off the sheet in the squeegee roll at the exit from the prior bath.

The final pretreatment stage utilizes a dilute chromic base acid rinse at approximately 130° F. In some installations, deionized water is used for a final rinse. As a final preparation for the actual coating operation, the strip is dried by forced air or heat and, in some instances, a combination of both. The purpose of the pretreatment is to provide a firm adherent base for the organic coating and to establish additional improvement in the service characteristics of both the base metal and the paint system.

Figure 5 illustrates the value of a properly applied conversion coating to two different aluminum alloys. The actual failure of the untreated panels started shortly after exposure and had continued to this extent after 104 months. It should be noted that even though the untreated panels have been exposed, the aluminum substrate has not experienced corrosion or surface degradation.

The painting application is made by a modern reverse roll coating machine which is enclosed in a room that is pressurized with filtered, thermostatically controlled air. The coil enters at the bottom of the machine and travels over the main drive and tension roll, up and over the steel back-up roll, and then out of the machine into the oven.

The top side of the sheet is painted by the double rolls. Paint is pumped into the pan or reservoir and is picked up by a chrome-plated steel roll and, subsequently, transferred and metered to the rubber applicator roll. The applicator roll rotates in the opposite direction of strip travel, and wipes the paint onto the sheet. In this fashion, all of the paint transferred to the applicator roll is applied to the sheet, and performance thickness variations due to slight metal thickness changes do not affect the paint performance.

From this point the strips travel upward and over a bottom coating head, identical to that on the top. Here paint is applied to the reverse side. This method makes it possible to use any combination of colors on either side simultaneously without transfer of the color on one side to the other.

Prior to entering the oven, a 25' length is allowed to run through, in order to permit the paint to flow, and some solvent to flash off before it enters the forced cure in the oven. The oven is a 130' four-zone, gas-fired, forced air system. The strip is unsupported through the length of the oven, since the paint coating on the bottom must be cured and partially cooled prior to supporting contact. The temperature in the individual zones is set to permit a rapid cure of the paint film, generally in the range of 60 to 75 seconds' duration.

Emerging from the oven, the strip is cooled to recoiling temperature in a water spray unit. At the exit of this unit, a guiding squeeze roll removes the water from the sheet before entry into the final drive bridle.

The final delivery equipment consists of four units: a main line drive bridle; an exit accumulator; a shear; and a recoiling mandrel. (Figure 6) The main drive bridle is a series of rubber-covered rolls which maintain preset speed and tension of the strip in the line. The equipment shown also feeds the exit accumulator which performs essentially the same as the entry accumulator. The one difference is that the floating carriage is normally in the bottom or unloaded position.

When it is necessary to shear and remove a coil from the rewind mandrel, the line continues to operate and, as the strip is fed into the unit, the carriage rises by hydraulic pressure, storing the production during the 60 to 90 seconds required to remove the previous coils. Upon completion of this operation, a motor driven bridle will overspeed and empty the accumulator onto the rewind mandrel.

In order to shear out the stapled splices and cut the coils to the size desired, another shear is in position. After the shear, the strip passes between a set of pass-line and tracking control rolls. From this equipment, the strip is fed into the rewind mandrel by the belt wrapper. The coil is removed from the reel by a pusher plate onto a hydraulically operated coil cart. The total length of the line is 320' and its capacity is a metal length of approximately 625' when completely loaded. The described facilities installed, exclusive of building, would cost in excess of $500,000.

The roll coating operation has certain characteristics and attributes which make it particularly desirable as a prefinishing method. The following paragraphs delineate some of these characteristics, but not in order of value or importance, since the particular circumstances of the individual company may place greater emphasis on one special condition.

The rate of production is dependent upon the design of the oven but, in general, a 60 second bake cycle in a 130' single pass oven will permit a 130 FPM rate of production. Since the operation is continuous, large volumes of production can be handled by a single line.

Paint utilization is such that waste or loss is confined to cleavage and the small amount that remains on the paint rolls. Paint utilization can be as high as 98% in a well controlled operation. Since paint costs are the major factor in prefinishing, the cost saving as compared to spraying can be significant.

As previously noted in the explanation of the coating head, complete versatility in color or gloss combinations is possible. Mixed or matched colors can be produced with equal ease.

In many applications, it is desirable, or even necessary, to provide different colors on each surface. Roll coating permits this type of production in a single painting operation.

The physical size of the finished product is, of course, dependent upon the design of the equipment used. The line illustrated in this paper will prefinish thicknesses from .006" to .064" and widths from 16" to 66". This range of sizes will meet the vast majority of specifications for materials used in construction and building applications today.

Product control through a single operation from bare mill coil to finished, coated material assures a high quality. The lack of handling and of multiple operations minimizes the potential of contamination or damage to the product. The controls and nature of the operation are such that it inherently reduces variation due to equipment or human elements. All of the control systems, from the pretreatment to the baking operation, are simple and precise.

The total manufacturing cost is reduced due to the continuous nature of the operations, the high utilization of paint, the minimum labor costs, and the low reject rate.

FINISHES -- QUALITIES AND AVAILABILITY

The range of qualities, textures and service characteristics of aluminum is infinite. The most common types of finishes available today are alkyds, vinyls, acrylics, epoxies, organisols and laminated vinyl sheeting, with the primary use being for exterior service applications.

The market and potential applications are so varied, that this discussion will be confined to specific applications and conditions which must be evaluated when determining the best product for the particular application or end use.

Since most exterior applications require a film which will provide maximum decorative protection, evaluation in those areas should be given the predominant consideration.

Selection of the type of finish, as well as the color, should take precedence over other less important factors.

In either residential or industrial construction, color and gloss retention, mildew resistance, chalking, dirt collection, and mar resistance should be given priority over such considerations as heat resistance, ease of fabrication, and unusual acid, alkali or solvent resistance. In the majority of applications today, the prefinished product is not subject to this type of service environment.

The finish applied, in general, must have a balance of characteristics. Serious thought must be given to insure that, for example, chemical resistance is not obtained at the sacrifice of chalking rate in an application where the product will not be subject to chemical attack. Another consideration is the availability of patterned or textured finishes, such as the various embossed patterns common to the aluminum industry. Some of these configurations, such as a wood grain pattern, require extreme deformation of the material and the organic coating. Therefore, it is often necessary to sacrifice some degree of durability to obtain the required degree of fabrication. Another consideration must be the dirt retention of patterned sheet and the difficulty of cleaning the surface. Also, the distention of the coating during the embossing operation will reduce the amount of forming which can be accomplished by the fabricator.

With the wide variety of patterns available, evaluation should be made as to whether the pattern has directional appearance. The common random patterns, such as stucco and leather grain, have directional appearance. In these cases, definite control in manufacture, fabrication and installation must be insured or nonuniformity of appearance can be evident in the finished product.

In most instances, the material supplier will have an adequate technical and engineering staff to assist in the proper development of new applications.

Due to the great number of paint manufacturers and variety of individual formulations, it is difficult to measure or accurately define the specific characteristics of any broad group of products such as acrylics, vinyls or alkyds. Rather, it is necessary to generalize on their relative characteristics.

Alkyds

For many years alkyds have been widely used in the precoating industry. They offer satisfactory (but not exceptional) exterior durability and ease of fabrication. Original cost of the material is comparatively low, but it is not sufficiently inexpensive for this to be a major consideration, particularly when cost per year of service is involved.

Vinyls

The introduction of vinyls to the precoated metal market provided improved forming characteristics, corrosion resistance, and exterior durability. These are particularly important when the substrate metal is prone to corrosion due to exposure resulting from microchecking of the coating in the areas of forming.

Acrylics

Previous Building Research Institute conferences have included comments on the introduction of acrylics and their improvement in exterior durability over some other coatings. Their fabrication ability is superior to the alkyds, and only slightly less than that of the vinyls. Of all the commercially available organic coatings, the acrylics appear to have the best balance of desirable characteristics for exterior construction applications.

COST AND SERVICE WARRANTIES

The cost to the fabricator of precoating is extremely reasonable in the common gauges used. Since a satisfactory service life of 10 to 15 years is being experienced, the cost per year of service makes it one of the best buys in the construction industry today.

Warranties are not normally provided covering years of service, since the paint manufacturers do not feel they can anticipate or define all of the environments or conditions that the product will experience during its life.

With the continual improvements in the substrate, the metal pretreatment, and the organic film, the paint industry should give some attention to updating its test methods and standards to express more meaningful values and conditons.

Product failures in service are difficult to evaluate. Misapplication or the overselling of a product's quality and attributes must often be considered as part of the over-all problem. As an example, a residence on the Eastern seaboard, two blocks from the Atlantic Ocean, was converted from white painted clapboard to green prefinished aluminum siding. Some two months after completion of the job, the home owner contacted the contractor about a white deposit forming on the green siding, and its objectionable appearance. On-site inspection by the paint manufacturer revealed that ocean spray had been blown against the home during a period of inclement weather, leaving a white salt deposit. This problem could have been solved, had the siding been frequently rinsed by hosing with fresh water, or had the original installation been a white siding on which the salt deposit would not be apparent.

In the few instances of field failure with which I am familar, almost all the material involved was produced 7 to 10 years ago, and represents a very minor portion of the market. A list of such failures would include:

1) Excessive chalking with an attendant stain on surrounding areas
2) Checking of the paint system
3) Premature or rapid erosion of the film
4) Dirt collection and spore growth
5) Premature loss of color and gloss

All of the situations listed have been improved or eliminated by technological advances in both the coatings and the application techniques.

REPAIR AND RECOATING

Since the finished surface on pre-enameled stock must, in many instances, survive complex and multiple post-forming or handling operations, some degree of surface damage may be expected. Touchup or repair of the material should be performed by properly preparing the surface with mechanical or chemical agents. Caution should be exercised, and a small piece of scrap should be tested before repair of an exposed area is attempted. Repair, whenever possible, should be restricted to small areas, and a brush just large enough to cover the area of damage should be used.

Repair, by spray or brush, over large areas is generally unsatisfactory, since color and gloss matching is difficult, and texture variations are prevalent. Additionally, the air-dry paint used will not weather in the same way as the baked enamel, and may present an unsightly, blotched appearance. Touchup or repair paint can generally be procured from the metal supplier, or the automotive touchup enamels that are generally available in most areas may also be used.

If it is determined, after a period of time, that it is desirable to repaint the structure completely, normal painting practices should be followed. This would include removal of surface dirt and contamination. If the surface is relatively new and still retains a high degree of gloss and luster, it may be desirable to use a liquid sanding agent to improve adherence. Caution must be exercised in selecting a solution, as some organic coatings are readily soluble in solvents.

The market and demand for prefinished aluminum are continuing to grow and expand. It is not impractical to visualize this product exerting a greater influence on the use of materials and color in building and construction.

Panel Discussion

Moderator: S.C. Frye, Application Engineer - Coatings, Research Department, Bethlehem Steel Company

Panel Members:

Messrs. Creighton, Godard, Hanson and Nelson plus
Harold R. Beckwith, Technical Director, American-Marietta Company
Donald K. Lutes, Sr., Section Supervisor, Precoated Strip and Industrial Groups, The Sherwin-Williams Company
Ian B. Packman, General Superintendent, Central Maintenance Engineering Division, The Port of New York Authority
John H. Geyer, Technical Assistant to the President, Amchem Products, Inc.

Harold J. Rosen, Kelly & Gruzen, Architects: How long will the coating last on your roofing and siding and what do you recommend for recoating?

Mr. Hanson: We have recoated sheets and also whole buildings when we were first in the experimental stage of this type of work. In certain atmospheres and under certain conditions, there will be greater deterioration of the film than in others. In these instances, the sheets should be given a thorough cleaning, checking whether the bond coating has gone, or just the top film, and, if necessary, scraping it right down to the galvanized surface again, and starting over with a field application. It is not expected that the service life of a field coating job will be as good as that of the factory job, principally because of the curing and drying operation.

Mr. Lutes: One thing that is very important is the amount of finish applied. In performance specifications this is usually listed, but the life of the coating depends to a great extent on the total film thickness applied. Most people recommend in the prefinishing of either ferrous or non-ferrous stock that the coating be in the range of 1 mil dry total film, at least. This is a very important thing in terms of long-term durability, particularly on roofing, curtain wall construction, siding, etc. In addition, as they have required it, we have recoated these materials with conventional type coatings; siding, for example, with conventional house paints. Our exposure work has been very gratifying and, generally speaking, most of the conventional coating materials can be used. As Mr. Hanson pointed out, you can never expect recoating to give you the type of durability the original system provides. Prefinished products are designed for the ultimate in erosion resistance, provided the proper film is applied.

R. H. Wood, Aluminum Co. of Canada, Ltd.: Can you describe the type of failure and appearance of the coating expected at the end of the anticipated 10 to 15 year life?

Mr. Nelson: This will depend, to some extent, on the environment. This is one of the problems that the paint and coatings industries have. If you were to expose the structure in a place where it was subjected to high winds carrying sand, as in the central part of the State of Washington, theoretically, you could sand blast the finish off one side of the structure before another type of failure might occur. In industrialized areas where there is air contamination, you may find other types of failures. So, this has to be evaluated in the service area which you are considering. Color and gloss retention are certainly major factors. There has been some evidence of peeling in the field, but this is generally evidence of failure to do a satisfactory job in the shop rather than a failure of the system as it was designed.

John Edwards, Durez Plastics: Do you consider your bond coat completely satisfactory or are you looking for improvement? If so, in what properties?

Mr. Hanson: Cetainly, we are looking for improvements of the whole system. We have experienced problems with it. I hope that we can solve them and ultimately produce a better product for our customers.

D. J. Struebey, Lilly Varnish Co: With your present finishing system, what do you feel are the main disadvantages of acrylic compared with pure vinyl finish coats?

Mr. Nelson: In evaluating a finish for our operation, we first of all considered the market in which we were going to sell, and this called for exterior durability. These factors, then, became predominant in our minds: color retention, and the potential rate of erosion. In effect, the major consideration was how long the finish would stay on the structure and perform its design function of protection and decoration. Based on everything we saw in the presentations made by the various chemical companies and paint companies, we felt that the color and gloss retention of acrylics provided the best finish. There are also certain cost advantages to acrylics. In our operation vinyl can cost as much as 30% more than acrylic material

Mr. Lutes: Depending on the operation, consideration must be given to when the material will be formed. With vinyls we have one advantage, I believe, in that they have good latent forming. In some instances this gives vinyl coatings an advantage over acrylic types. In an operation where the material is going to be formed at a later date, favorable consideration should be given to the use of vinyls. Of course, the basic acrylics have been modified today so that there are many types, and a great deal of improvement in flexibility has been realized. Some day we may reach the point where the acrylics will compare very favorably with the vinyls. In fact, in many instances today, they do.

Mr. Beckwith: I would certainly agree that the acrylics have better color retention on exposure. I am not sure that I would agree that their erosion rate is better than vinyl. There are data to support the fact that vinyl coatings will erode at a rate of between .02 and .03 mils per year. Assuming that you start with the 1 mil dry film, this means it would take 13 or 14 years for the film to erode to a point where it begins to lose its protective qualities. We have no data on the erosion rate of acrylic, but we do feel that the erosion rate of vinyl is extremely low and certainly compared to alkyd coatings and house paints, it is very much lower.

Mr. Frye: A number of questions have been raised relating to film thickness which, I believe, were not thoroughly discussed in the preceding papers. Perhaps Mr. Hanson would like to add some remarks on film thicknesses and finished coatings.

Mr. Hanson: In our specifications every effort is made to provide for a total dry film thickness (bond coat plus finish coats) of 1-1/4 mils. This is based principally upon the advice and consulting service of our suppliers. As I indicated, we are in the building business, we are not paint experts, but this seemed reasonable according to the data available.

Mr. Nelson: As Mr. Lutes pointed out, strip coating has normally and historically been applied in a one mil nominal thickness. We attempt to hold to this. Nine-tenths to one actually is the range within which we like to operate. It is difficult in a roll coating operation, in a single pass without double coating, to build a very high film. One mil has been satisfactory, and I think we can prove that it need not be any higher than that.

T. W. Henderson, United Steel Fabricators: What problems have you experienced, if any, in fading of colors after a period of exterior exposure?

Mr. Nelson: If we were to establish a standard group of colors, we would select good colors and good pigmentation for color retention. The colors which we promote and try to sell as standard have been selected this way.

Mr. Hanson: We haven't experienced many problems with fading, with the possible exception of our accent color, orange. This is a cross between an orange and a red, and it has posed the greatest problem. Originally, our whole range of standard colors and their compatibility with each other were designed for us by a group of industrial designers in Detroit. They chose a set of colors and our suppliers did the best they could to match exactly each color selected. With additional research they have come up with others which we feel are much better, but orange is really the only one that has given us any problem.

Mr. Beckwith: You can generalize to the extent of saying that the darker shades perform better in terms of color retention than the pastels. This can be attributed to a number of reasons inherent in the formulations.

Mr. Lutes: The customer and the paint supplier must work together, pooling their information and their exposure data to come up with the best color. Basically, most of our colors for curtain wall construction, siding, roofing, and building components have given very good performance. We've had good color control and, generally speaking, very good field performance. This is a result of the information gathered through the years and also of keeping up to date on the new pigments that are developed.

R. Caplan, Midland Industrial Finishes: What are the effects on paint film of improper or irregular conversion coat treatments? Does age of conversion before painting affect performance?

Mr. Nelson: If we do not have a good pretreatment of untreated aluminum, the degradation or the loss of film is extremely rapid.

Mr. Geyer: Chemical conversion coating is an inorganic film that is usually applied between the aluminum surface and the organic paint. It performs a number of functions. As paints become more and more sophisticated, and particularly as we get harder and harder films, we find that nonuniformity of conversion coating -- coating weight or coating thickness produces differentials in adhesion. Apparently, as these films cure, lateral stresses do occur in the paint film. They shrink, primarily, and if there are various thicknesses of coating, it is possible that the paint will become stronger than the conversion coating and will shear through the conversion coating in those areas where the coating is thickest. Also, if there is nonuniformity or nonexistence of coating, particularly in some of the aluminum alloys, there may be migration of metal ions into the organic film. There must be a barrier coating sufficient to prevent migration of such things as magnesium ions into the organic coating, as this will cause embrittlement of the bond.

Mr. Hanson: We use what is generally termed a wash primer which, by its general nature, enables us to bond coat, and then stack and finish coat at a substantially later date. We have not experienced any problem in field service, perhaps because of the film thickness, or the fact that the sheets are already preformed before the coating is applied.

Mr. Geyer: To go on a little bit about age on coatings. Some people feel that there is a definite time limit in which a chemical conversion coating can be painted. Chemically and technically, this is not so. The Government has panels on buildings that were treated eight to twelve years ago, which have been painted with some of the newer paint systems, and they perform as well as freshly prepared stock. The same is true of steel, galvanized iron, and aluminum. The big headache is not the degradation of the inorganic film itself, but the accumulation of surface contamination that usually occurs when a chemically treated sheet stands for a long time in the plant prior to the application of the paint.

Mr. Lutes: We have found in our routine laboratory work, particularly on treated aluminum purchased as coil stock and not coated for four or five months that, if it is kept clean and not contaminated we get very good performance. So, there doesn't seem to be a critical time limit in this regard, based on our laboratory and exterior exposure work. However, from a safety standpoint we generally like to see material coated in the field as soon after metal treatment as possible. This is generally the way it's handled in the factory. Usually, however, our results have been very good on stock that has been aged, and particularly on aluminum.

Mr. Beckwith: In the case of hot dipped galvanized steel strip which has been pretreated and stocked by us for panel work, we do have problems with age. As the strip ages, we have trouble coating it because of gassing.

Mr. Lutes: There is a greater problem with phosphatized hot dipped. You probably have to take a little more care in the exposure work than with treated aluminum.

J.C. Bryan, DuPont Finishes Division: Has field experience with steel buildings indicated no problems with edge rusting? Has solvent resistance been a problem in the field when cleaning off excess caulk at joints? Has your vinyl system shown good color retention in the field?

Mr. Hanson: Edge rusting has not been a particular problem to us. Bear in mind, the basic panel is a galvanized sheet to start with. It is run through the galvanizing process as a sheet, so the edges are galvanized, and we do not shear it to a narrower width. Therefore, we have a basic steel sheet completely enclosed in the zinc coating, edges included. Our color coating system is applied so that it actually overruns the edges to a degree. There has been no particular problem with edge rusting, certainly no more than was ever experienced with galvanized sheets themselves.

Mr. Frye: Suppose the panels are cut in the field?

Mr. Hanson: If they are cut in the field, there is a possibility of edge rusting, as there will be an edge of bare steel remaining. The galvanizing itself will protect this for a period. The coating system will not be undercut to any substantial degree. Certainly, the whole appearance of this coated sheet and its performance is an improvement over what bare galvanized sheets would give you in the field, but you still have the same inherent problem with cutting, damage, etc. As for removing mastics, in our standard line of buildings and in their erection we use a rope sealer. This is a preformed material which, properly applied, doesn't have to be cleaned off. It doesn't adhere to the coating or have to be cleaned off with solvents.

Mr. Frye: How thick is your zinc coating?

Mr. Hanson: Our basic specification for the galvanized steel conforms to ASTM A-361 with the nominal 1-1/4 oz. standard commercial galvanized coating.

Mr. Frye: Have you done any work with thinner zinc coatings?

Mr. Hanson: Yes, slightly thinner, but there hasn't been a great deal of difference in the performance of the two except in the resultant allowable life service of the galvanizing itself, the galvanized sheet, and the coating of zinc. Actually, our system is a combination approach designed to provide color and aesthetic appeal as well as some additional protection through the film. There was never any thought given to elimination of the galvanized coating and the use of only the vinyl film. This is a plus feature, so to speak, of the panels on our buildings. This is our approach to it and the galvanizing provides the basic reserve capacity for wear and effectiveness against the elements.

Unsigned question: What methods can be used in industrial buildings for the maintenance of precoated siding?

Mr. Packman: I haven't had much experience with precoated siding. However, we don't anticipate any problems other than the same problems we encounter with galvanized corrugated sidings where, after five or 10 years, you have to give it a thorough cleaning and then spray paint it. As far as cleaning is concerned, I see no reason why the majority of these prefinished sheets can't be cleaned with water or a mild synthetic detergent, similar to the detergents used for cleaning automobiles.

Mr. Nelson: The degree of maintenance given to a finish on a structure will certainly prolong its life. Proper maintenance will add much, not only in total years of service, but in the continued aesthetic appeal of the finish.

A. Mack, Rosco Products, Ltd.: In roll forming embossed aluminum we have found the coating is removed from the tops of the embossed ridges. Can you comment?

Mr. Nelson: In our operation the painting is performed on the flat or unembossed sheet. It is then embossed and the necessary post-forming is done next. In the embossing operation there is a severe deformation of the film and the metals by the patterned rolls. In the rewrapping of the film, unless the tensions and rewrapping are precisely controlled, some cinching or take-up can occur in the coil, and cause the voids or the scrape-off on the top of the embossed pattern. We have undertaken programs of interleaving to minimize this effect. We recommend that the embossing be rather shallow, if the embossed pattern is used. Through better electric controls on the equipment itself, we are minimizing this. What we don't eliminate by process control, we do by inspection control.

Mr. Frye: Perhaps Mr. Lutes or Mr. Beckwith can comment on vinyl dispersion organosols. What do you think of their future?

Mr. Lutes: Our work with organosols and vinyl dispersion coatings has been very gratifying. We've compared these with the solution vinyl types in which we have a great deal of background. We feel that the dispersion type coatings have a very good future. We, as well as many other paint companies, have run into problems in the field. These coatings have some disadvantages which, I am sure, will be surmounted in time. Some of them, particularly in the low gloss range are metal-marking to a greater extent than the solution vinyl types. Down in the gloss range of 10 or below they tend to metal mark more. The clean-up of this metal-marking, which might be due to handling or dragging sheets across each other during installation, is more difficult. Certainly, exposure-wise, they have given a good account of themselves. We'd say they are on a par with the solution vinyl types. Our results with color have been very good. Formability in the low gloss ranges has been better than that achieved with the solution vinyl types. So, they have a plus in flexibility and, of course, the big plus, if they can be used, is in the economics. They will be considerably more economical to use than the solution vinyl types, but we still have some work to do on them. We have several test areas, test homes, etc. where siding has been painted with the dispersion type coatings, and the results promise to be very good. One other problem has been that of bringing down the low angle sheen to the finish. The organosol types tend to have a little higher low angle sheen. In some cases this is not favored for siding and that sort of use.

Mr. Beckwith: Our tests for durability indicate that the organosols are the equivalent of solution vinyls, and perhaps have a slight plus value. One advantage which has not been mentioned is that they are easier to apply on reverse roll coating of coil stock. This is due to the higher volumetric solids at coating viscosity.

T. F. Harland, Pittsburgh Interlock Tile: In our experience mildew and spoor growth on organic finishes is becoming an increasing problem. Could the panel discuss this from the standpoint of prevention and removal on the job?

Mr. Lutes: With the alkyd types of coatings there is always a possibility of spoor formation or mildew growth. The solution vinyls, however, have been very good in their resistance to mildew. We have many exposures throughout the country, not just panel exposures, but installations on homes and buildings, and we've had very few complaints of mildew growth. This is primarily our experience with the acrylic types also. It depends on the coating and on the location. We have built in some mildew inhibition in all these coatings, and we are trying to improve this all the time. The solution vinyl types literally have nothing for the mildew to live on and this, of course, is a big step in arresting or discouraging mildew growth, as contrasted to oil-modified films, alkyd types, and others which support mildew growth. Of course, airborne mildew will grow and adhere to almost anything, even glass, and this you cannot arrest.

W. A. Higgins, Lubrizol Corp: Are there prefinishing paints available or under development which do not require conversion or bond coats for adhesion?

Mr. Beckwith: I don't know of any but, naturally, we are working on this sort of thing. This is part of our effort to reduce the cost of prefinishing the metal substrate, but at the present time there are no coatings available, to my knowledge, which are satisfactory without the bond coat or conversion coating.

Mr. Lutes: The only thing I might add is that the use of a primer at times has increased the fabrication or formability of a material.

Mr. Geyer: I believe that ultimately such a finish will be developed. However, even though a finish were developed that would perform satisfactorily without an intermediary coating, you would still be faced with the problem of cleaning your strip or your fabricated part prior to the application of the top or finish coat. Looking at it from the standpoint of economics, most installers first use an alkali degreaser which has to be rinsed off. I am sure no one is going to develop a paint to put over residual strong alkalies, so you water rinse the surface, which is the second stage. Then, in most instances, there is a third stage that acidifies the water on the surface. If you were to stop there, you would still be faced with drying the strip or the sheet prior to the application of the top coat. In chemical conversion coating, by the simple addition of two stages which require no more drying or heat, you can obtain a coating from an aqueous solution, and it is relatively inexpensive. Ultimately, therefore, I believe that finishes will be developed to replace chemical conversion coatings, but they will have to be very economical if they are to supplant inorganic conversion coatings.

Frank L. Couch, Architect - Engineer: Sometimes it becomes necessary to prime raw or mill-finished sheets or extrusions. What preparation methods and what type of primer should be used?

Mr. Geyer: There are several specifications, both government and industry, that call first for brush-cleaning using a phosphoric acid base cleaner to remove the oxide. The phosphoric acid contains wetting agents to remove grease, finger prints and other organic soil. This step is followed by a hosing down with water, followed by a brush application. In the case of aluminum, a chromate treatment of the same type that is used in the mill is applied, then water rinsed and allowed to air-dry. In the case of steel and hot dipped galvanize, the same precleaning method is used. The chemicals are somewhat different but, again, they are brush applied. These systems have been satisfactorily used in the field for 20 to 25 years.

Mr. Beckwith: Standard primers for application to properly cleaned surfaces are available for field application. The choice of primers depends strictly upon the environment to which the finish will be subjected. If the atmosphere has a high chemical content, an epoxy primer or a chemically resistant primer is used, whereas for normal field use, you can use alkyd or combination alkyd and oil-base.

C. F. Huddle, General Motors Corp.: Is there any suggested method by which one can determine life expectancy of a color in a particular locality?

Mr. Lutes: Even the many extended resistance tests that we run don't always tell exactly what you would like to know about exterior durability. For example, resistance tests in laboratories, weatherometer tests, etc., can only be used as a guide. They are valuable when you are comparing performance versus a known. And, even in these cases, we've had reversals. We've had good performance in extended resistance testing apparatus and yet, have run into problems in the field. It is necessary to project what you think a material will do based on background experience with similar materials and pigments. If we are not sure of a color which a customer desires, we pretest if for six months on exterior exposures in various localities along with the laboratory tests before going ahead. At least this provides some idea as to how it will hold up because, usually, the greatest changes occur in the first year. We rely most on actual exposure tests at locations scattered throughout the country. Many colors prove to be only minor deviations from a known and established color. Then, you can more or less extrapolate the results.

Mr. Beckwith: There are two principal reasons for repainting: one is appearance, and the second is lack of protection. Some finishes and some colors show more change, more chalking, than others. They become unsightly after different lengths of time. If the owner of a building decides that he doesn't like its appearance any more, he will repaint. In this case, he will usually repaint before he has actually lost the full protection of the original organic coating. If appearance is satisfactory, and he reaches the point of repainting because of lack of adequate protection of the substrate, this will, in the case of vinyl, be after about 13 or 14 years.

Unsigned Question: In the 15 - 20 year estimates of durability, have any data been obtained to prove that erosion rate will remain uniform throughout the life of the film? Can erosion rate be accurately determined in the first two years of exposure?

Mr. Beckwith: You have to make the assumption that the factory finished product had the originally specified mil thickness. Or, if you are going to make an actual test, you measure the film thickness at time of installation or just prior to installation. It is a simple matter to measure film thickness at yearly intervals, or at any other interval that you so desire thereafter.

Mr. Lutes: In this regard we have studies underway. Unfortunately, they weren't started 10 years ago, but only about seven, so we don't have too much background. Knowing the importance of this, we are now, in most of our exposure work, keeping records to gain this information. Some 10 years ago, we made some exposure tests on solution vinyls and found that our average loss of film was around .2 mils in seven years. This level was maintained quite uniformly on this particular set of tests. Primarily, these tests were conducted on siding finishes where mostly nonchalking pigments were used. The rate of erosion was quite uniform as I would expect it to be. Some of these exposures have now existed for 13 to 14 years and show an average film loss of about .2 mils in seven years for solution vinyls.

A. D. McCall, Alcan: Do you have experience on the cost of maintenance of the exterior of warehouse buildings, particularly those that have employed precoated stock?

Wm. Lukacs, YMCA Natl. Bldg. Service: Dealing with "exposed" type use as you do, what has been your experience with these prefinished materials?

Mr. Packman: To date, we haven't had any particular experience with these prefinished sheets. The only applications we have used have been corrugated galvanized. We merely painted those the same as we would structural steel. These prefinished sheets have all only been in use for two or three years. We haven't had any trouble or any problems as yet.

J.C. White, Inland Steel Products Co.: Has any work been done on a transparent protective coating applied over the finish coat which can be removed after erection?

Mr. Nelson: We have applied a transparent strippable finish over a painted finish, as well as over bare aluminum. It is applied in the same manner as the paint, and can be peeled off after erection or at some intermediate stage of fabrication. It increases the unit cost and therefore, depending on the ability of the contractor to erect with minimum damage without the protective film, it would be a question of economics. I don't know how it would work out on low gloss film. We have not coated any low gloss films with this material, but we did notice a change in the gloss level when we applied the strippable finish over the organic finish.

Mr. Hanson: It should be recognized that these materials are limited to use with thermosetting coatings rather than thermoplastic, because if you apply them over a thermoplastic coating you can't strip them off.

Wm. M. Lukacs, YMCA Natl. Bldg. Service: Do the heavier gauges of aluminum lend themselves to deep forming on double coated sheets satisfactorily without splitting the finishes? Do you use resilient forming rolls to do this?

Mr. Nelson: A limited amount of drawing can be performed without damaging the film surface. We have not produced any quantity, to my knowledge, that was actually subjected to a true drawing operation. If you get into something like this, trial work is certainly in order since the tooling itself may not be adequate to handle the prefinished sheet.

J.F. Gosse, Bethlehem Steel: What are the time and temperature required for drying organic/inorganic bond coat?

Mr. Hanson: The temperature is about 250° F. The period of time in the over is relatively short. The line moves at about 80' a minute. This is a relatively thin film, however, and with that temperature it dries sufficiently to permit it to be stacked and handled for the next operation.

Carl Nocka, Enjay Chemical Co.: You mentioned a coating of approximately 2¢/sq. ft. What additional cost would be incurred for a second, 0.5-1.0 mil coat, which presumably would not involve a conversion or other pretreatment? What increase in life expectancy might result?

Mr. Nelson: The cost would be about double, or approximately 4¢/sq. ft. in that case. This would certainly limit the postforming which could be performed, as a built-in film will show a corresponding decrease generally in formability. You would have to use a conventional primer under it, and I don't think you could use the same type of material for both coatings. Possibly an epoxy primer could be applied followed with one of the more conventional coatings for the finish film.

Frank J. Sieja, Lilly Varnish Co.: Why do you find it necessary to preheat the panels prior to painting?

Mr. Hanson: This is in the interest of uniformity throughout the rest of the process. We are located in Terre Haute, Indiana, and weather conditions vary considerably. We have a very large plant which is not uniformly heated and this is the easiest way to get a uniform item with which to work, thereby eliminating some of the adjustments that would have to be made in other phases of the operation.

PREFINISHING OF NONMETALLIC SUBSTRATES

Session Chairman -- J. S. Long
Executive Director
Paint Research Institute

Prefinishing of Wood and Composition Board

By Don F. Laughnan,* Section Chief,
Coatings Research, Simpson Timber Co.

Factory priming is not practiced extensively in the lumber industry, although segments of the industry have been priming and treating wood products for a number of years. We may consider the millwork industry to be one of these, if we define the term "finishing" as including treatment with water-repellent preservatives. It has been treating its millwork with such solutions for about 25 years, and several years ago began applying paint primer to its treated millwork.

Special hardboards, made for use as exterior siding, were primed by the manufacturer as long ago as the early forties. Since the mid fifties, hardboards, fiberboards, and particle boards have been produced in a sealed, filled, primed, or completely finished condition. A wide variety of finishes, the nature and composition of which are determined by the use for which the board is intended, can be applied by special equipment.

The cedar shake manufacturers, about six years ago, undertook to apply primer to their product. Originally, an oil-base primer was applied with a rotating brush to individual shakes. This was followed by an infrared bake of two to three minutes duration, after which the shakes were packaged in ventilated cartons to permit the primer to oxidize and dry further while in storage or in transit. More recent techniques involve gluing of the individual shakes to a backing of plywood or composition board. The shakes are then primed or completely finished, generally by automatic spray equipment. Some manufacturers apply a single coat of polyvinyl acetate or acrylic emulsion paint; others, two coats of such paint. Still others use an oil primer, followed by a latex topcoat, and a few apply a complete alkyd resin finish.

It might be said that these methods of finishing were adopted as a matter of necessity. Most millwork is made of Ponderosa pine which is largely sapwood and vulnerable to decay. Too, the manner in which millwork is constructed produces joints in which water can become entrapped to give rise to decay, swelling, and premature paint failure. Treatment with water-repellent preservative is necessary to overcome these shortcomings. The application of paint primer to millwork was undoubtedly brought about by the demands of builders interested in minimizing the time required to paint the millwork at the site, as well as by pressure from competitive products.

Hardboards and fiberboards are difficult to prime or finish by hand, but relatively easy to prime and paint with automatic equipment. Particle boards generally need to be filled in order to render them smooth, and filling is a laborious task. The manufacturer, by taking care of these tasks in his plant, produces better boards that find much wider application than do raw boards.

---

*LAUGHNAN, DON F., B. S. in Chemistry, University of Wisconsin; Member, Federation of Societies for Paint Technology, Forest Products Research Society.

Cedar shakes are relatively porous and difficult to paint uniformly by hand. Moreover, a great deal of work is required to erect individual shakes. Therefore, finish is applied in the manufacturer's plant to a number of shakes attached to a backing made of plywood or composition board. This, again, is an example of a forward step; one made to produce a better engineered product to meet the demands of the consumer.

Until recently, no such progress was made with wood siding, one of the more important, if not the most important of the building materials manufactured by the lumber industry. It was manufactured decade after decade without change. With all of the painting remaining to be done after the siding was in place, the lumber industry relied on the paint industry and on those who applied the paint to make a well engineered construction material of wood siding. In effect, the lumber industry persisted in offering its siding as a raw material. Unfortunately, the manufacturer of the siding had no control over the painting, so the final step required to convert the siding to an acceptable engineered material was beyond his control.

To make matters worse, technological advances in other industries resulted in the development of competitive sidings, the painting of which is under rigid control by the manufacturer. These sidings were obviously better engineered materials. In addition, they meet the building contractors' demands for building materials requiring less on-site labor, a demand prompted by increasing labor and real estate costs.

These factors, in addition to the early failure and prohibitively high maintenance cost of finishes on wood siding, brought about a serious decline of the wood siding market. One of the nation's leading siding manufacturers recognized this and eight years ago took steps to correct the situation by dipping its siding in a water-repellent preservative. The treatment, as demonstrated by the U.S. Forest Products Laboratory, prevents capillary penetration of rain water and dew through joints in the wood siding, thereby eliminating one major cause of paint blistering. Despite this effort, the wood siding market continued to decline.

This was the situation until two years ago, when our company put factory-primed redwood siding on the market. This move was made only after consultation with numerous paint companies and paint raw material suppliers, none of which had developed a proven primer for the purpose. However, one manufacturer recommended a primer made with a short-oil alkyd resin. This recommendation was based on the excellent performance of coatings made with this resin on metal. At that time, there had been no experience with the primer in an application such as we planned.

This primer is pigmented with rutile titanium dioxide, basic silicate white lead, talc, and diatomaceous silica. It is formulated at a pigment volume concentration of 50%, and the thinner in the primer is entirely xylol.

Other lumber manufacturers followed us into factory priming. Most of the wood siding now being primed is redwood and Western red cedar, but some Western hemlock siding is also being primed, and at least one manufacturer is priming exterior grade Douglas fir plywood.

In addition, several manufacturers are priming medium density, paper-overlaid Douglas fir plywood.

The lumber siding industry has now become extremely conscious of painting. Only the larger lumber manufacturers are thus far doing their own priming. The smaller siding manufacturers have their siding primed by custom finishers, of which there are now several in the Northwest and West. The actual application of the primer is done either with spray equipment or with a curtain coater. Most manufacturers preheat their siding prior to application of the primer and, subsequently, force-dry the primer, generally with infrared heaters. The equipment for priming roughly 50,000 feet of siding, during an eight hour shift, costs between $60,000 and $70,000.

The primer which we have described continues to be most extensively used, although similar short-oil alkyd resins are now on the market. Most paint manufacturers would prefer to see the lumber industry use primer with a medium or long-oil length alkyd resin, and considerable work is being done to make primers made with such resins dry faster.

Let us now discuss the priming process itself. Our company's process is quite representative of the priming processes in use in the lumber industry, the major difference being that our primer is applied in two steps or two coats, the first of which is brushed. I believe all other manufacturers use a one-step process in which the primer is applied in a single application.

We spray the ends of the siding in stacks before the siding enters the paint line. The total in-line time in our priming line is 14 minutes, 12 seconds. The siding piece enters the first preheater, a ceramic infrared heater, in which it attains a temperature of 120-125°F in 36.5 seconds. The conveyor then carries it to and through a curtain coater where a water repellent of our own formulation is applied to the back or underside of the piece.

17 seconds later, it enters a second preheater in which it reaches a temperature of 115-120°F. Here the water repellent is dried and, simultaneously, the face of the siding is preheated. Then the siding piece passes through a board turner which flips the smooth or planed face up. It then passes through a second curtain coater where the primer is applied in one-mil (wet) thickness. The partially primed piece now passes under a rotary brush which distributes and brushes the primer onto the surface.

The partially primed board moves on to a third preheater in which the temperature of the primed surface is elevated to 150-155°F. Seconds later, it is conveyed through a third curtain coater where the balance of the primer (about 3-1/2 mils, wet) is applied. The coated siding is then conveyed through two flash-off or predryer units and into the first of four infrared dryers erected in series.

In the first dryer, the primed surface is brought to a temperature of 95-100°F in approximately 30 seconds. With intervals of 25 seconds between heaters, it reaches, successively, temperatures of 105-110°F in the second heater, 135-140°F in the third heater, and 145-155°F in the fourth. It then moves through a cooling section for three minutes and three seconds to the packaging station where it is slip-sheeted with polyethylene film, and wrapped.

The cedar siding manufacturers use a similar priming process but apply the primer with airless apray rather than with a curtain coater. The general practice is to apply the primer at 1.5 mils dry film thickness. We apply our primer at two mils dry film thickness.

I am sure that any qualified paint man would take the position that a factory primer, made with a long-oil alkyd resin, should provide better durability and more reliable performance in the field than one based on a short-oil alkyd resin. Wood siding manufacturers agree, but must compromise because of application time limits. Fortunately, cracking has not been a problem with our primed siding, though we have had it on the market for more than two years. This has amazed not only us, but most paint people who are familiar with its performance. I believe its performance must be attributed in part to the inherent properties of the primer, and in part to the good dimensional stability of vertical grain redwood and red cedar.

Factory priming provides advantages for the siding manufacturer, the paint manufacturer, and the user of primed wood siding. A quality primer, applied under optimum conditions, results in a uniform coating that is thicker than that generally applied at the site. This frees the house owner or painting contractor from the burden of selecting the primer, and prevents the abuse to which unprimed siding is too often subjected before primer is applied in the field.

The prime coat reveals defects, such as fine splits and raised grain, that escape detection in unprimed siding. These can then be eliminated, with the result that the buyer of primed siding actually receives siding of better quality than does the buyer of unprimed siding. Factory priming also eliminates the possibility that the primer will be applied to wet siding. In addition, factory-primed siding meets the demand of builders and contractors for siding materials that require less on-site work.

The manufacturer of wood siding can prime it at lower cost than if it were to be primed at the site. Factory-primed siding sells at the retail level for about $54 per M sq. ft. more than unprimed siding. We are told that a reasonable cost of applying a primer to wood siding at the site is about $80 per M sq. ft. of surface measure. This, then, represents a saving of approximately $50 per house to the builder or the ultimate owner.

While we are discussing the advantages of factory-primed siding, let us briefly consider our reasons for priming in two steps rather than one. The primer we use is made at 50% pigment volume concentration, and excessive pinholing was a problem for us. In our efforts to overcome this, we resorted to applying the primer in two steps, the first followed by brushing with a rotary brush.

Subsequent tests revealed other advantages, some of them more important than the reduction in pinholing. One of these is the deposit of a more uniform coating, having a slower rate of erosion and providing better hold-out of topcoats. Such a coating is also less vulnerable to cracking and to penetration by water. This penetration can dissolve the water-soluble color extractives in the redwood and carry them out through the paint film. Wood siding manufacturers, in general, feel that factory priming of wood siding is a great step in the right direction. Most paint men with whom I have consulted concur, primarily because the practice permits control over the application of the primer. Such control has always been lacking in field application of primers and topcoats.

Much as we have been encouraged by the performance of our primed siding and by its acceptance, we are well aware that some problems remain to be solved. The final finishing or topcoating of factory-primed siding is beyond the control of the siding manufacturer. The painting contractor and the houseowner, who select and apply the topcoat paints, too often permit the primed siding to weather too long before applying the topcoat.

Factory-primed siding, topcoated with a generous coat of oil-base or alkyd-resin-base paint, performs very well. Most siding manufacturers recommend two coats of latex paint over their primed siding to provide equivalent durability. Unfortunately, with all types of paint, the general tendency is to apply too little. The paint industry has long faced this problem and siding manufacturers, offering primed siding, now share the problem.

Finally, the topcoat paints offered by the paint industry for use on wood, are not as durable as the user would like them to be. We are convinced that one coat of such paint, applied over factory-primed siding, will out-perform and outlast a similar system based on primer applied in the field. But this is not good enough. To meet its competition, the lumber industry must be able to offer painted wood siding, on which the paint will outlast and out-perform the paints of today. To make this possible, the limitations imposed by conventional topcoat paints for wood must be overcome.

These factors serve as incentive to the wood siding manufacturer to completely finish the siding in his plant. Considerable work toward this objective is under way. Some of the wood siding manufacturers, who factory-prime, already have test houses sided with completely factory-finished siding. Medium-oil length alkyd resin as well as acrylic emulsion topcoats are being tried. Some experimental work is being undertaken with thermosetting paints applied to wood siding and to modified wood siding, but this work is still in the preliminary stage. Various integral films that may be laminated to wood are also being studied.

Trends in the wood siding industry indicate that the lumber industry has decided to make a real effort to regain its siding market. More encouraging, though, than development of factory priming of wood siding, is the evidence of a new attitude in the lumber industry -- a cognizance of the fact that its major competititon is in engineered materials. We may expect, in the near future, to have wood products and combinations of wood and other materials that are first-class, engineered construction materials.

Prefinishing of Masonry Concrete Block

By John A. Sergovic,* Vice President and Technical Director,
The Burns and Russell Co.

Introduction

It is important that there be an understanding of the basic factors governing the prefinishing of masonry or concrete block. Most people who become interested in the matter of facing concrete block generally think only in terms of appearance. Their common goal is to devise methods that will cover or hide the base block and, through the use of color, gloss, speckles, or marbleizing effects, make the facing attractive to view. After 12 years of experience, our company has learned that appearance, although important, is in reality a minor consideration. The facing must have an attractive appearance to gain the attention of the architect but, unless the facing has the chemical and physical properties needed to allow it to withstand from 20 to 30 years of hard use, its original appearance is of little value.

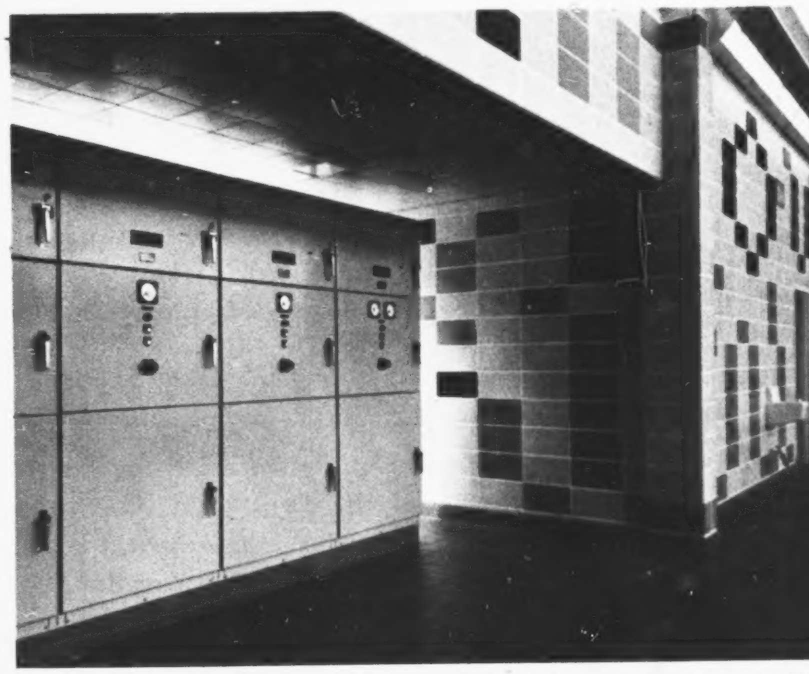


Figure 1. Glazed masonry units used for wall of industrial plant

It would appear that there should be a wide market for concrete block, and particularly for faced concrete block, for use on the exterior of buildings even though the block manufacturer competes in the market with producers of wood, metal, and glass. However, our experience indicates that aside from brick there is very little small-unit masonry used for this purpose. It is a common practice for architects to specify either glazed or unglazed brick. On occasion, terracotta is used. Also, there is a tendency to use large, precast, custom made concrete slabs. The use of unit concrete masonry for exteriors, except for the residential market in the Southeast and Southwest, has not been extensively adopted. Consequently, our knowledge of and experience with the exterior application of prefaced masonry concrete units is limited.

---

*SERGOVIC, JOHN A., graduate in Chemical Engineering, Newark College of Engineering, post-graduate work at Columbia University; Member, ASTM.

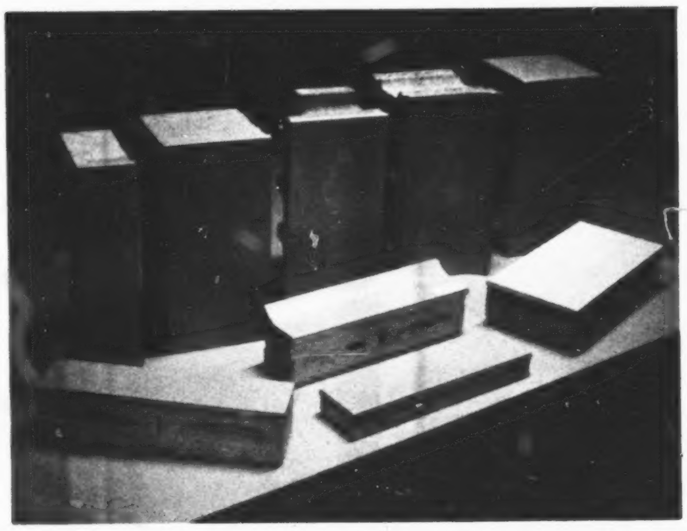


Figure 2. Various prefaced cast units

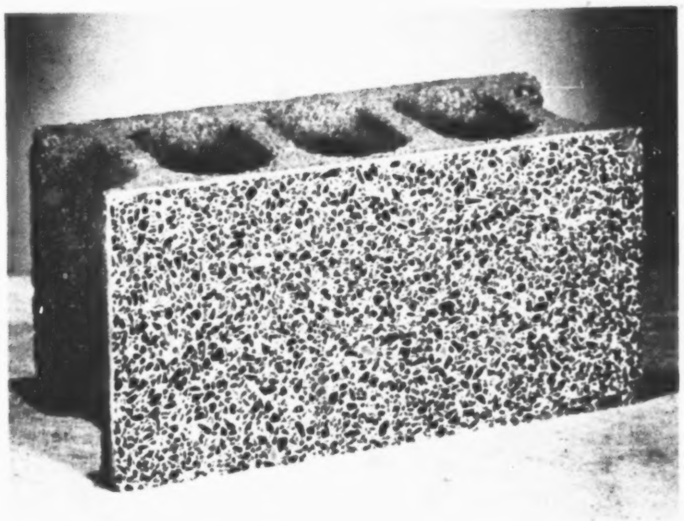


Figure 3. Terrazzo faced unit

The major use of glazed masonry units of any kind, to date, is on the interior of buildings, (Fig. 1) although some exterior use has been made of prefinished concrete masonry blocks. In either case, the use of any prefinished concrete block may run into competition from a glazed clay unit, especially structural glazed tile. This product is manufactured to very high standards, and has been used by designers for many years. Therefore, they generally think in terms of glazed tile whenever they have an area where cleanliness and low maintenance are required.

It is my feeling that anyone contemplating the prefacing of concrete block must first think of building into such a facing those physical and chemical properties that are equal to the properties of structural glazed tile. Second, he must produce a facing that is attractive in appearance. It is important to keep in mind that designers of buildings use masonry because they expect masonry units to last without maintenance for 20 years or more. Consequently, the prefinished concrete block must have the following qualities:

1) Chemical and physical properties that will allow the product to be used for 20 or 30 years, under constant abuse, without deterioration such as staining, crazing, discoloring and similar effects detrimental to appearance.

2) An initial appearance that will make owners and designers want to use the product.

3) Provision for suitable shapes so that builders may erect structures with a minimum amount of cutting and fitting around doors, under and around windows, and at floor level. About 70 shapes or fittings are produced in glazed clay units to satisfy this need, in one face size alone, and there are five face sizes.

Processes Currently in Use

Over the years, several processes have been developed for finishing and facing concrete block. These can be placed in three general categories: casting, spray laminating, and grinding.

Casting - The formation of a facing through means of a casting process is most common. In the casting process, the facing material consists of pigment; a filler, generally a mineral aggregate such as crushed rock or sand; and a thermosetting resin which is used as a binder. Because of its particular working characteristics, the binder generally used is a polyester resin. There are various versions of this process, but all of them require that the mixture be placed in a mold; the block placed on top of the slurry; and then a curing operation. The different methods of casting a face are as follows:

1) Casting a face through the use of heat.

2) Casting a face using a room temperature set followed by grinding.

3) Casting a face using fiberglass as a reinforcement, with the fiberglass or decorative sheet creating a pattern in the facing.

4) Casting a face by forming:
   a. First a gel coat in the mold,
   b. Followed by addition of metallic flakes,
   c. Followed by a background colored layer.

Facings are being made using cement as a binder in place of resin. In this process, block and facing are cast simultaneously and allowed to harden and cure in a steam atmosphere for about eight hours. After initial set of the concrete, the faced unit is removed from the mold and the facing is either waxed or oversprayed with a clear resin coating. The facing is generally marbleized.

Spraying - A second basic process for producing a prefinished concrete block involves the use of spray coatings. Various types of finishes are produced by spraying the raw block as indicated below:

1) Through the application of a neutral filler-sealer coating consisting of a filled polyester followed by:

   a. Grinding operation to smooth filler coat,
   b. Spray application of a color coat,
   c. Spray application of a clear surface coat.

   These operations produce a smooth, high-gloss facing. In this process it is necessary to grind all four edges after the various coatings are sprayed, and cured with aid of heat.

2) Another high-gloss facing is produced by using colored aggregate or by highly tinting the surface of a concrete block followed by:

   a. Grinding the surface to expose the aggregate,
   b. Preheating the block surface,
   c. Heavy spray-coating the block surface with a clear polyester.

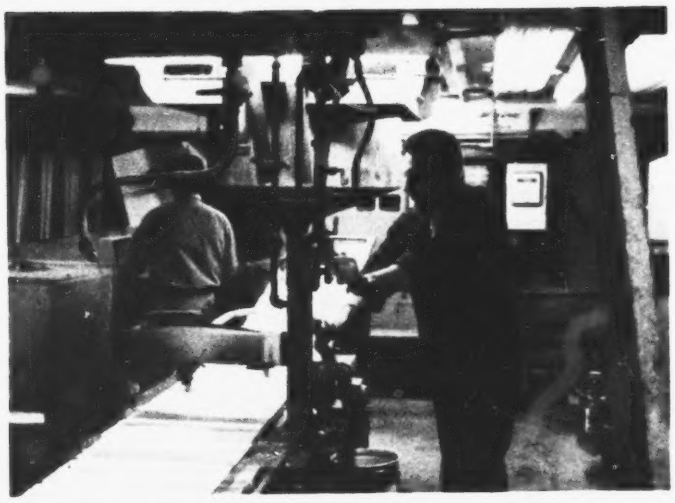


Figure 4. Mold loading process

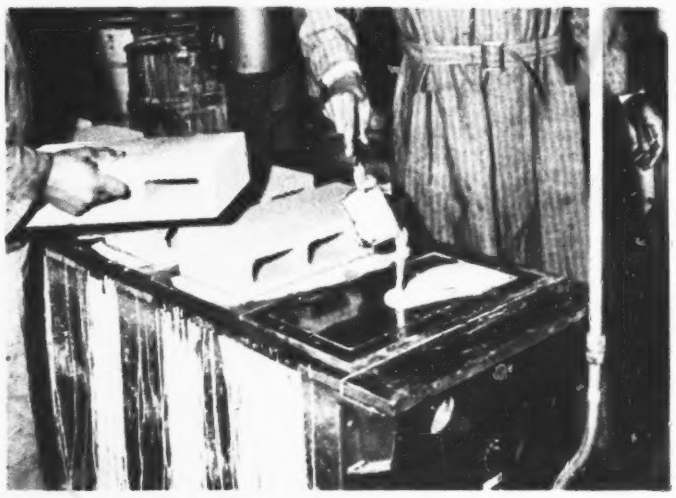


Figure 5. Hot plate loading process

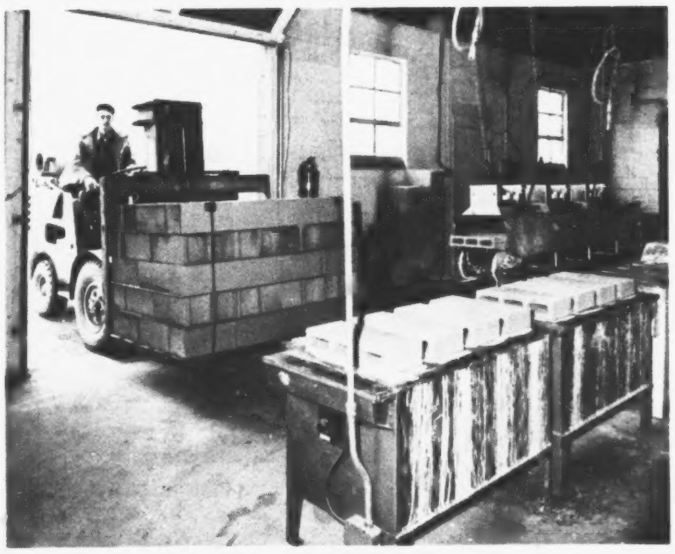


Figure 6. Hot plate plant

3) Spray application of a colored baking enamel, utilizing a melaminealkyd, directly to the preheated surface of a block, produces an acoustical block. The application of a colored coating which does not seal the porous surface of the block permits retention of excellent acoustical properties.

Grinding - Several large producers of concrete block and artificial stone slabs have produced a prefaced concrete block by using color aggregate and grinding and polishing the face. This technique is the least common of the three mentioned.

Process, Equipment, and Capital Investment

To date, the greatest interest in prefinishing concrete block has centered on the various casting methods. Plants utilizing an oven for curing resinous mixtures (Fig. 4) are designed to produce 5,000 units per eight-hour shift. The total capital expenditure for all necessary equipment is about $60,000.00. The manufacturing area required is approximately 12,000 square feet. Another process producing a cast facing utilizes a hot-plate or heated mold technique (Figs. 5 & 6). The production of this type of equipment is 300 units per day. The equipment is rented. Plants utilizing room temperature set and grinding of block faces after curing have a capacity of approximately 500 to 700 units per day. These plants require a capital investment of $10,000.00 to $15,000.00.

In a now-abandoned process which used fiberglass as a reinforcement, a clear polyester was first poured in a mold. Following this, a fine glass mat or decorative paper was placed on the gel coat. Then, a highly filled, colored, polyester slurry was poured on the gel coat. After this, a heavy glass mat was applied. The block was then placed on top of the assembly. Mold and block were then placed in a cylinder press equipped with a bottom heating platen. Cure was accomplished in about three minutes at 15 psi.

In the process where cement is used as the binder, and the facing of the block is made simultaneously, the machine producing one block and face at a time has the capacity of 800 to 1,000 units per eight-hour day. The capital investment for the entire block and face-making machinery is $15,000.00 - $20,000.00. In the process utilizing spray technique for prefinishing concrete block, there is much variation in equipment and capital expenditure, all of which depends on the nature of the finish being applied. In the process in which the acoustical properties are maintained, the equipment required is an automatic, transverse spray machine and a continuous oven. Investment is about $25,000.00 and production is 5,000 units per day. In the process in which a block is ground and sealed with a filler coat, followed by a color and a clear coat, some very extensive material handling equipment is required. It is reported that the total cost of such a plant, designed to produce 5,000 units per day, is over $100,000.00.

Cost Comparisons

As a general rule, although prices will vary in different parts of the country, the average selling prices of unfaced concrete block are as follows:

1) An 8'' x 16'' size unit 4'' thick will sell for 15¢

2) An 8'' x 16'' unit 8'' thick will sell for 24¢

These same units, after they have been faced, will sell for about 60¢ above the cost of the block. When comparing these prices with those of structural glazed tile, it is to be remembered that the clay unit is made with a face dimension of 8'' x 16'' but it is limited in thickness to 4''. The 4'' thick glazed clay tile unit sells for approximately 66¢ per square foot. At the present time, glazed concrete masonry units of thicknesses greater than 4'' do not have a counterpart among clay units.

Nature and Types of Failures

One of the basic factors that must be considered when deciding on the finish for a concrete block is the element of long service. When a structure is erected of masonry materials, its walls can be expected to endure for many years. If, for any reason, the facing becomes unsightly, a very real and serious problem is created. It is generally impossible to take out the wall, particularly if it is load-bearing. This problem is unlike that presented in the case of the deterioration of paint, which can be corrected by recoating. This is particularly true in cases where there has been exterior application of prefaced masonry. Over the years, the glazed clay tile industry has developed a specification, ASTM C-126, that has insured good results for walls made of this material. Since it has served as a guide for glazed masonry walls over many years, it should be recognized as at least a minimum standard for coatings or facings for concrete masonry as well. Unless a block facing can meet these minimum requirements it will, in all probability, fail to do the job intended over the years.

Some of the job difficulties and failures our company has encountered are as follows:

1) Staining of face - It has been found that walls are subjected to a great variety of materials capable of producing discoloration. Many materials, such as greases, oils, crayons, lipstick, beverages, gravies, and sauces may, in different areas, come in contact with a wall. In many instances, these materials are allowed to remain on walls for many days before they are removed. After long exposure to these materials discoloration can occur, particularly if the facing is at all absorptive or is in any way porous or pitted.

2) Cracking due to thermal change - Even though a block is intended for interior use, it can be subjected to temperatures ranging from -20° to -30° and up to 120° F. During the course of construction, prefaced concrete blocks are often delivered to a job site and remain outdoors, often unprotected, for many months. Particularly in the northern states, it is common for material delivered in September, when temperatures range in the 80's and 90's, to remain outdoors throughout the entire winter, when the temperature will drop as low as -20° F. The facing must be able to withstand the continuous thermal shock caused by many cycles of freezing and thawing.

3) Color variation within a wall - This is probably one of the major sources of trouble. Unless very elaborate precautions are taken to insure that each block produced is of the same shade as every other block, a very unsightly finished wall may be erected because masons will not do inspection work. Reports from producers of faced concrete block, particularly that produced by the casting technique, disclose that maintaining color uniformity is one of the most difficult problems that they face.

4) Exterior yellowing - Two chief types of failure of prefaced concrete masonry units in exterior use are the yellowing, due to ultraviolet radiation, that occurs when a resinous facing is used, and the dulling that takes place because of caulking or surface erosion.

Repair of Finish in the Field

Our experience to date indicates that the repair of a prefaced concrete masonry unit in the field produces highly undesirable results, and at the very best is extremely difficult to do. Units made through the grinding technique can be repaired through additional grinding, but the cost is comparatively high. In the case of faces produced through casting alone, it is virtually impossible to patch or make perfect repairs at any cost. In general, it is best to discard an imperfect unit. In the event such a unit actually gets placed in the wall, it is far better to chip the unit out and replace it with a thin slab rather than try to correct it by means of patching.

Probable Future for Prefinished Masonry Units

It is our belief that, if the quality of prefinished units is maintained at a level sufficiently high to insure that these units will give good service, their use will increase and the prefinished masonry business will expand. If, on the other hand, sufficient consideration is not given to quality, and all emphasis is placed on original attractive appearance, as it has been in the past, the inroads that prefaced concrete block have made in the wall market will disappear. The trend in prefaced concrete units will be toward blocks that have faces of greater dimension than 8'' x 16''. The present desire of architects is for large slabs, both for interiors and exteriors. The sizes requested of us are 4' x 8' or 4' x 16', light in weight, and load bearing.

Prefinishing of Cementitious Materials

By Robert E. Parry,* Senior Section Chief and Manager,
Professional Personnel, Johns-Manville Research Center

Introduction

Prefinished asbestos-cement materials, factory-coated with organic coatings designed to meet exterior exposure conditions, are rather recent additions to the line of commercially available building products. In just a very few years, these factory-coated products have gained widespread acceptance, and represent a substantial part of the business of manufacturers of coated shingles, boards, and panels. Use of these new color-coated building materials will undoubtedly continue to increase.

This paper will be limited to a discussion of the factory application of organic coatings to asbestos-cement products. No attempt will be made to discuss the various types of inorganic coloring treatments which have been used, such as the colored cement veneers; the so-called "ceramic coatings", which are based on soluble silicate binders; colored granules imbedded in the surface; or products which are integrally colored by incorporation of pigments in the entire composition.

Although the development of prefinished cementitious products for exterior service is new, manufacturers have had considerable background experience in the application and use of protective and decorative coatings on asbestos-cement products for interiors. Too, there have been many years of actual field exposure history of exterior coatings applied on-the-job to various types of asbestos-cement products.

As far back as the 1920's, several manufacturers of asbestos-cement board produced varieties of coated board for bathroom and kitchen walls, wainscoting, basement rooms, and similar applications. Various types of asbestos-cement partition panels, with factory-applied coatings or surface laminates, have been available for many years. Perforated asbestos-cement acoustical tile is also well known.

A great many of the various types of asbestos-cement products used for exterior exposures have been field painted, and it has been necessary for the manufacturers of these products to develop painting specifications or specific painting recommendations. The manufacturers of paints and coatings have been very helpful in this area.

---

*PARRY, ROBERT E., B. S. in Chemistry, Middlebury College; Member, ASTM, BRI.

Types of Asbestos-Cement Products Used for Exteriors

Asbestos-cement products which have been developed for exterior use may be listed as follows:

1) Flat sheets of varying thicknesses and compositions.
2) Corrugated sheets of varying thicknesses and compositions.
3) Siding shingles.
4) Roofing shingles.
5) Low-density boards.
6) Sandwich panels of asbestos-cement face sheets with lightweight insulating cores.

Each asbestos-cement product essentially consists of a mixture of asbestos fiber and portland cement, formed under pressure into hard, rigid sheets. The compositions may be modified by variation in the ratios of fiber and cement, by the addition of mineral fillers, or by the substitution of organic fiber for some of the asbestos fiber. Densities may be varied by formula modification or by a change in forming pressures.

Manufacturing Processes

Three different types of manufacturing processes are used to make asbestos-cement products

1) Press Process - In this process, a slurry of fiber, asbestos, and water is poured into the cavity of a mold which has a slotted bottom plate and a perforated screen over the plate. Hydraulic pressure on the top platen of the mold forces out most of the water and compresses the mixture to the density desired. This method is used for the manufacture of sheets 1/4'' or more thick.

2) Hatschek or Wet Process - The Hatschek or wet process is the most common method used in the manufacture of thin, flat sheets and shingle stock. The equipment is similar in principle to that of a cylinder paper machine. Successive thin layers of the asbestos-cement mixture are picked up from a dilute slurry of the mixed ingredients by a cylinder mold, or molds, then transferred to an endless felt belt, and transferred again from this belt to a mandrel of suitable circumference to produce the length of sheet desired. The wet-lap sheets are removed from the mandrel and stacked. For some types of board, to provide further consolidation, the wet sheets are pressed again in a hydraulic press.

3) Dry Process - The so-called ''dry process'' is used by some manufacturers in the production of siding and roofing shingles. In this process, all the dry ingredients are thoroughly mixed in heavy duty dry mixers. The dry mixture is deposited in a uniform, fluffy layer on an endless rubber-faced conveyor belt, gradually compressed by means of roll pressure, moistened with just enough water to permeate the mass, and then consolidated into a dense sheet by means of massive pressure rolls.

No matter what type of equipment is used to produce the sheets, asbestos-cement compositions require some type of curing process after formation. "Normal-cured" products are simply piled in stacks and allowed to air cure for about a month in a damp atmosphere. During this period the cement hydrates, and the panels become hard and strong. Curing of asbestos-cement compositions can be accelerated by the use of high-pressure steam in a suitably designed pressure vessel. This method of curing in an autoclave is extensively used in the industry. "Steam-cured" products have a slightly different composition of ingredients, the principal difference being in the addition of a percentage of finely ground silica to the mixture. Under suitable conditions of temperature and pressure, this silica will react with the lime released during hydration of the portland cement to form additional calcium silicate. Steam-cured products have better dimensional stability, and are much less aggressively alkaline than normal-cured products.

Factory-Applied Finishes for Exterior Exposure

The asbestos-cement industry has entered into the manufacture and sale of factory-coated products by gradual, cautious steps. This is natural and understandable, for asbestos-cement products are basically durable and weather resistant. There are no known organic finishes which can be expected to have as much durability as asbestos-cement. However, over the years, enough information has been built up to clearly show that asbestos-cement products provide an excellent base for the application of properly designed exterior coatings. Asbestos-cement does not rot or corrode as do wood and metal. Because of its excellent dimensional stability in comparison with wood, some of the hard, very durable types of coatings, which would not be satisfactory for use on wood surfaces, may be used with asbestos-cement.

Potential problems due to the alkalinity of the asbestos-cement sheet have been eliminated by advances in organic coating technology and by the development of coating vehicles and color pigments that are not alkali-sensitive. The introduction of new types of efficient production coating equipment has contributed toward making the application of organic coatings economically practical.

1) Factory-Primed Products - About five years ago, a line of factory-primed asbestos-cement board was introduced to the building trade. The development of this product was caused by field problems which developed in the application of paint over unprimed board, particularly on board-and-batten type of houses, (Fig. 1) where the asbestos-cement panels were used in combination with wood battens and trim and were painted at the same time as the wood. It was found that, regardless of the manufacturer's recommendations, the painters would use any paint they wanted to; or, if they used the recommended materials, they would not apply them properly.

   The primer for this factory-coated board is an alkali-resistant, rubber-resin lacquer, formulated to accept either conventional oil or alkyd-resin exterior paints or emulsion paint topcoats. Carefully controlled factory-coating procedures make it possible to be certain that an adequate thickness of coating is applied to provide an alkali-resistant barrier coat and good holdout of the topcoats. This preprimed product has had very satisfactory field acceptance. Factory-primed siding shingles have also been produced and sold. These are ready for painting in the field with any type or color of exterior house paint topcoat.

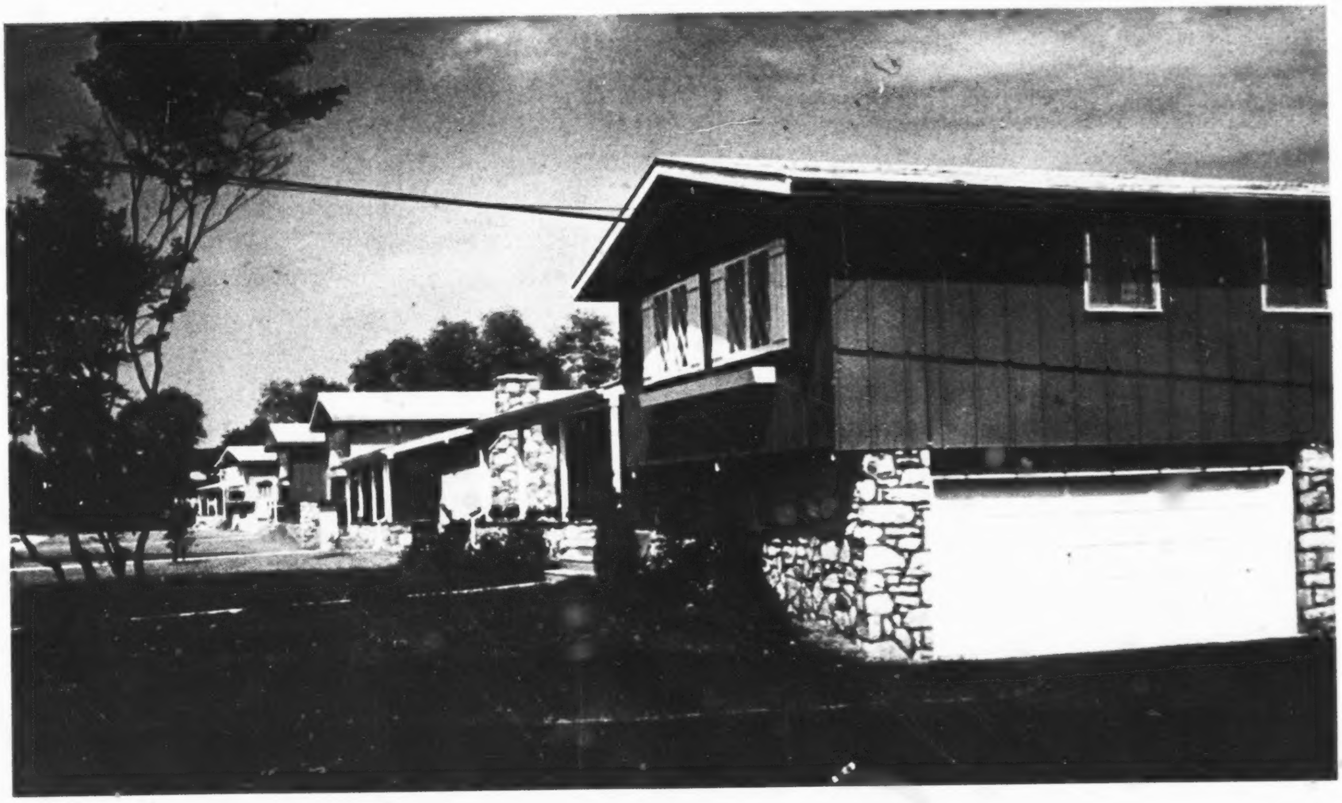


Figure 1. Typical installation of preprimed asbestos-cement board used as sidewall material on a board-and-batten type house, field painted.

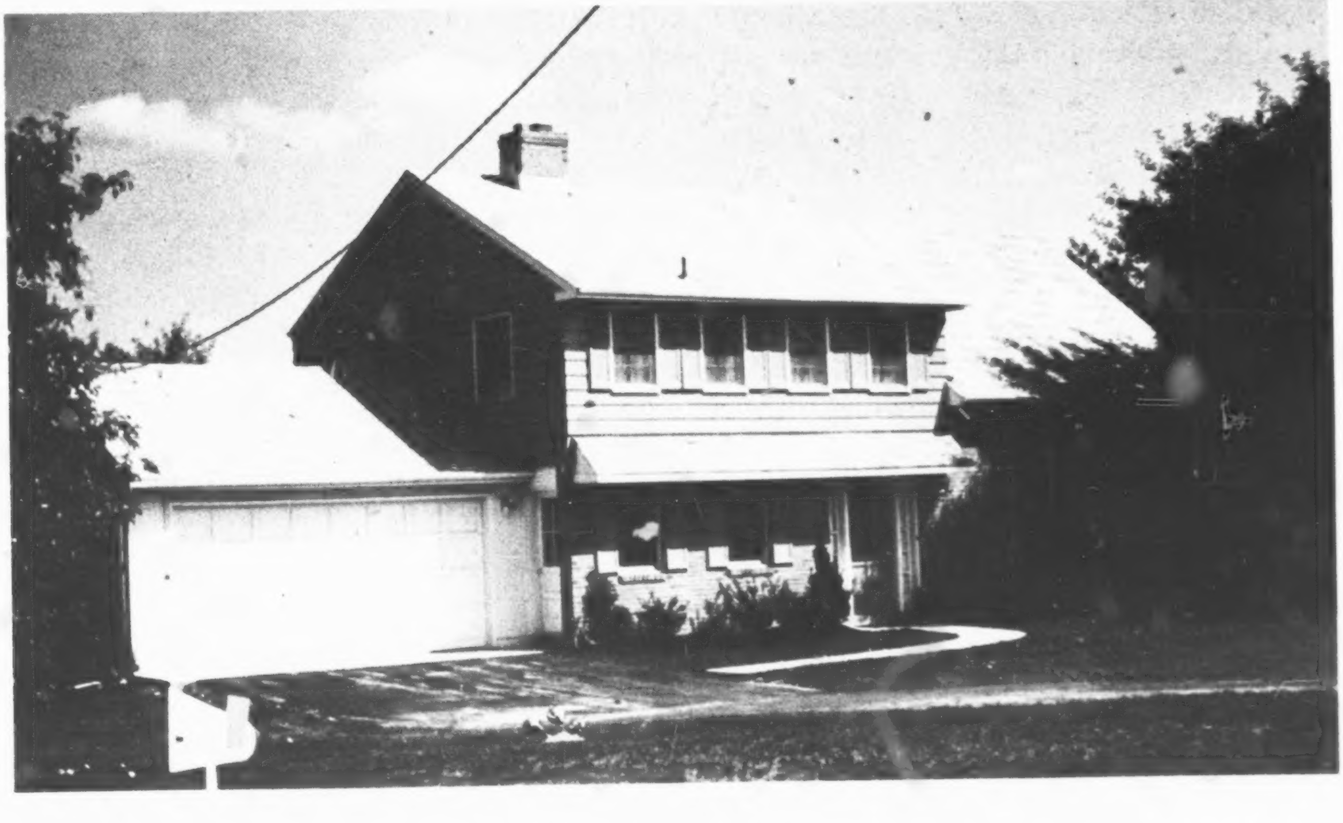


Figure 2. Typical installation of prefinished asbestos-cement siding shingles.

2) Factory-Finished Siding Shingles and Board - Most of the manufacturers of asbestos-cement siding shingles now produce shingles that are factory-coated with decorative, organic finish coatings. They are available in a range of colors, sizes, and textures. The decision to market this type of product was made because it was realized that present-day home builders demand clean, bright colors which cannot be obtained by any practical means other than surface coatings (Fig. 2). The shingles are sold with the definite understanding that the color coats applied have excellent durability but will, in time, require repainting, and that suitable refinishing paints are readily available on the market.

Nearly all of the shingle manufacturers use acrylic-resin materials because of the known durability and color stability of properly formulated, pigmented acrylic coatings. The coatings may be either emulsions or solvent-thinned acrylic lacquers.

Regardless of type - emulsion or solvent-thinned lacquers - the coatings designed for factory application must meet several very specific requirements. In addition to the obvious necessity for good initial appearance and good outdoor durability, they must retain their good appearance for a period of many years without excessive color fading or heavy chalking. The coatings must be hard and abrasion-resistant, so that the shingles or board can be packaged, shipped and handled on the job without marring or surface damage. The economics of the building business is such that it is not practical to provide special wrapping or packaging to protect a surface that is easily damaged. These requirements necessitate the use of harder grades of acrylic resins, and a precise adjustment of the pigment-to-vehicle ratios.

From the standpoint of appearance, the industry prefers low-gloss coatings for exterior siding. We have found that 60° gloss readings of 6-10 and 85° sheen readings of 3-5 are about right. Readings lower than these may cause trouble with "rub up" of the coating during handling and shipping, and present the appearance of color variation. High-gloss finishes are undesirable because they magnify even minute surface irregularities.

There are special color control problems, both with the coatings as purchased and with the finished products. It is necessary to insist on much closer control of the color of incoming shipments of paint than is normal in the case of most industrial or trade sales coatings. Similarly, it is necessary to maintain very close control of the thickness of the coating applied during manufacture in order to insure uniformity of color and gloss, both of which are sensitive to film thickness variations.

For practical factory application, the coatings must be adaptable to a high-speed production coating operation. Hence, the coatings must be of a type that can be either baked or rapidly force-dried, and thus permit packing of the coated products immediately after drying. The coated products must not block or print during storage under loads of up to 20 psi.

These are, of course, generalizations. The details of coating formulations and the methods of coating application will vary among plants. For example, our company produces coated shingles at five plants. Three of these plants produce coated board as well as shingles. In one plant, we use acrylic emulsion coatings; in the other four, we use solvent-thinned acrylic lacquers. We selected the lacquer type coatings for the greater part of our production of coated products, because we had many more years of outdoor exposure history with lacquer coatings than with the newer emulsions. We apply two coats of the lacquer on a continuous conveyor line by means of tandem curtain coaters, with each coat force-dried in an oven. The coated shingles are cooled and packaged immediately on emerging from the oven. Large sheets are coated on the same equipment as the shingles.

Costs

The costs of material and labor for applying organic coatings to asbestos-cement products vary somewhat among manufacturers, depending upon the type of coating process used, but they are considerably less than the costs of field application. The major point of importance is that asbestos-cement shingles, prefinished with high-quality organic coatings, can be sold for the same price as uncoated shingles, or at a very nominal premium. Costs for on-the-job painting would range from 5-10c per square foot.

Durability Characteristics of Prefinished Products

All laboratory tests and field-exposure results indicate that prefinished shingles and board have excellent outdoor durability. It is doubtful that any manufacturer would guarantee their durability for a fixed number of years, but it may be expected that factory-applied coatings will have longer life than commonly used exterior house paints applied over wood siding. Weathering tests show that the coatings fail by gradual surface erosion, and that, when repainting is necessary, the weathered surface is a satisfactory base for the application of either emulsion or oil-base exterior paints.

After about two and half years of field experience with these prefinished products, our company's results may be summarized somewhat as follows.

Prefinished shingles have been acceptable to builders both for new house construction and for replacement of the siding of older houses. They are attractive, economical, durable, easy-to-apply siding materials. The preprimed and prefinished sheet products have had their largest use to date on the board-and-batten type of house in which the sheets are used in combination with wood or asbestos-cement batten strips.

There have been very few field complaints and these have been due largely to minor surface damage and color variation. Experience has shown that as the applicators become accustomed to handling the coated products, the number of reports of chipped or scratched shingles has decreased and this is no longer a real problem. For some time, we supplied small aerosol cans of touch-up lacquer to take care of scratches and chips caused by handling or by a careless hammer blow, but we have discontinued this practice as no longer necessary.

Color variation problems can result in complaints which are troublesome and annoying, but not serious, because these are only appearance problems; not actual coating failure. It requires constant vigilance on the part of plants and laboratories to maintain the degree of color control necessary to stay free of complaints. We are very pleased with progress in this direction.

Conclusion

We consider the development of factory-prefinished asbestos-cement siding as a logical step in the steady growth of these products as useful construction materials. It is consistent with the general trend in the building materials industry to provide better value in terms of quality and speed of construction. Engineered application equipment has made it possible to use on plant production lines certain types of modern finishes that could not be applied as uniformly or as economically in the field as they can be applied in a factory. The builder and home owner are thus provided with decorated siding that is well suited to provide years of good service and appearance. Selection of finishes has been made not only for durability, but also for repaintability, since it is recognized that home owners will often want to repaint for the pleasure of enjoying a fresh new color, even when the existing paint is sound.

Panel Discussion

Moderator: Martin Nosenchuk, Director, Architectural Division,
Rayco Mfg. Co.

Panel Members:
Messrs. Laughnan, Sergovic, and Parry plus
George O. Lloyd, Jr., Partner, Perry, Shaw, Hepburn & Dean, Architects,
W. L. Hancock, General Superintendent, Martin-Senour Company

J. R. Danner, Shawinigan Resins Corp.: What are the flammability characteristics of polyester faced block and, if it is flammable, how can you justify the use of these blocks in institutional buildings?

Mr. Sergovic: A properly designed facing for a concrete block must pass the requirements stated in E-84, the tunnel test generally recognized by most building code authorities in the United States. I know of about five such codes which dictate exactly what the flame spread can be for the type of building in which you want to use a particular product. Unless you know what your flame spread classification is, according to E-84, you can't justify the use of such a product under the existing law. It is quite well spelled out for each particular type of building in each area in the U.S. and it runs anywhere from a flame spread of 20 in some areas for institutional buildings, up to 75 in others.

P. E. Caron, Weyerhaeuser Co.: Which of the finish systems have shown the best outdoor durability on the asbestos board?

Mr. Parry: Over the years we have tested almost every known type and three years ago we chose an acrylic coating. We chose the lacquer, because we'd had more years of experience with it than with the emulsions. The emulsions are very good, too. There are other coatings which are very durable but which do not retain their appearance as well. They either chalk, or have more color fading.

Mr. Hancock: We, in the paint industry, would essentially agree with what Mr. Parry has said. The polymers, i.e., the acrylics, PVAs, etc., all perform very nicely. The reason we, in the paint industry, are so interested in them is that the integrity of the film, that is, the behavior of the paint film on exposure is rather amazing. We don't underestimate the alkyd type coatings and the chlorinated rubber coatings at all, but we still would have to say that the over-all ratings of the polymers are really superior.

M. D. Phelps, Benj. Moore & Co.: Is there any reason why emulsion or latex paints, as classes of materials, regardless of type of resin used, have not been successfully used for priming wood siding?

Mr. Laughnan: The reason we do not favor the use of latex primers on redwood siding is because they have color extractors which are water soluble. Almost immediately, when the latex primer comes into contact with the surface of the redwood, the extractors are drawn from the wood into the prime coat. I might add that it's bad practice to apply a latex primer to a wood surface, if you can't control the type of top coat that's applied over it, because a tight top coat is apt to separate from that primer. Also, you generally can't obtain from a latex primer the film thickness that you can get from an oil base primer. We feel that the increase in the number of latex top coats forces us to build a protection for the surface into our prime coat. We do this to better advantage with the solvent base type of primer.

Unidentified speaker: We, in the paint industry, keep hammering away at the importance of the primer. From no emulsion have we ever been able to get the guaranteed adhesion which comes from the good penetration provided by solvents.

A. A. Hill, Dow Chemical Co.: Has any progress been made in solving the fastening problems associated with completely prefinished siding materials?

Mr. Laughnan: We have tried only two test houses with completely finished siding, and in these we used an acrylic emulsion over an alkyd resin base primer which was applied in our research laboratory. We prefinished 5,000 feet of siding this way, and then gave the siding to a specialist in wood siding erection. We tried the NLMA fastener and we tried the California Redwood Association fasteners. I think I'd like to sum up our experience along this line by saying we still have some distance to go. The people who have been erecting wood siding are committed to use of the nail. We may find, as the aluminum siding people did, that this is not the method of fastening which we should apply. My feeling is that we may have to train fabricators to erect completely finished siding. Other members of my company are not in complete agreement with this opinion.

Mr. Parry: I do not know of any way by which you can erect really thin sheets without having some fastener which will show. If the sheets are sizeable it would be possible to cut boards into narrow widths which have some sort of a clip behind them, but 4' wide sheets could not be fastened in this manner.

There are things that can be done with composite sheets. You can erect sandwich panels in channels, or in a frame, or with extrusions which will fasten the sheets together. This is being done in 4' x 8', 10', and 12' lengths, but I would not know of any easy way of doing it with 1/8" or 1/4" panels.

Mr. Lloyd: The only comment that I would have about erection is that the manufacturer should try to educate the general contractor, the superintendent, and the workers on the job about how to protect the material. What we are discussing in this conference is finished material, and our major problem during construction is keeping the finished material clean so that the completed job will be acceptable. I think the fasteners are a matter of detail. When larger units are used, they will tend to conceal the fasteners.

Mr. Sergovic: What method of quality control is used to insure against off-shades in production, outside of laboratory control?

Mr. Parry: We have pre-shipment samples sent to us. They are approved in the quality control laboratory. The drums are checked again, and drawn out samples are matched against the color standards. Therefore, we have had to insist on a much tighter control of color than is normal in the paint industry. The usual trade or industrial paints would not be closely enough controlled for our type of work. Many of our color problems are probably more our fault than the fault of the paint manufacturer. The coating machines should be kept clean, there should be no contamination when you change colors, and you should be very sure that you apply the same amount of paint hour after hour.

P. S. Pinckney, E. I. du Pont de Nemours & Co.: What is the minimum practical pot life for a composition to be applied by casting?

Mr. Sergovic: You can't afford to have a production system in which you have a pot life problem. There are too many things that can happen during a day in the course of the manufacture of from 2,000 to 4,000 units of block. In our system, material will last one or two days. A pot life of only an hour or two is just not practical when you are trying to make faced concrete block in large quantities.

Robert A. Wilson, Ellerbe & Co.: Are concrete block available with a true ceramic facing? With cast polyester resin facing, how do performance characteristics compare to those of a structural glazed tile?

Mr. Sergovic: There are some concrete block being produced with ceramic facings, at least experimentally. I don't know that anyone is producing them commercially to date, but I am told that there is a real possibility of a practical ceramic coating on a concrete block. The performance characteristics of structural glazed tile are based on ASTM C-126. A glazed concrete masonry unit must match the performance of a tile meeting this specification. Otherwise, the glazed structural tile or ceramic glazed tile will be a better product. I think that a face concrete unit can be and is being made to do everything that this specification calls for.

Mr. Nosenchuk: From the point of view of specifying structural glazed tile and watching it being used, how do you feel about this particular question?

Mr. Lloyd: I never considered ceramic glazed tile to be in the class of concrete block. I think it is a mistake for the concrete block people to try to get in to the ceramic tile business. I don't think that a concrete block as a back-up can compare to the ceramic tile block.

Thomas P. DeWan, General Electric Co.: When wood siding is nailed into place, what priming do you recommend for the nail heads?

Mr. Laughnan: We have offered in aerosol containers, a version of our primer which can be applied over nail heads. However, nobody is taking care of these nails as we would wish. This is one of the reasons why we want to work out some other method of attachment.

Mr. Nosenchuk: Mr. Hancock, what problems have you run into with reference to field applied finishes when the nails are not primed properly?

Mr. Hancock: Professional painting contractors share with us our concern over touching up and repair of nail heads. We have found no type of paint that will hold up over iron nails and other types of nails that are carelessly selected. Not knowing what type of finish coat is going over the prime material, it is necessary to stick with either an oil type or an alkyd type material to touch up nail holes. If you are using an oil emulsion finish coat, obviously, you cannot do any touching up or repairing with a water emulsion material.

Harold Rose, Reliance Varnish Co.: What accelerated tests have you found to correlate with actual outdoor exposure on wood, if any?

Mr. Laughnan: We are using 25 tests, each of which is open to criticism. I selected them on the basis of a quarter of a century of experience with paint coatings and I won't argue for any of them. On the other hand, I would probably criticize other tests suggested by anybody else in the paint industry.

Mr. Nosenchuk: Have either Mr. Lloyd or Mr. Hancock anything to add on that point?

Mr. Hancock: That is our problem in the paint industry right now. We've got a lot of catching up to do. For all these years we have accepted the basic theory about painting wood siding which states that it takes from 24 to 48 hours after the primer is applied before you can put a top coat on it. Now we are trying to figure out how we can cut the 24 to 48 hours down to 6 or 7 minutes. I think that we need to develop a realistic type of accelerated weathering method. Actually, when they began factory priming with an alkyd type formulation on wood, they had no basic exposure background. They decided to take a calculated risk and they won, we hope. I think we've got to do the same thing because, if we want to be realistic, what we are competing with and what the lumber manufacturers are competing with now is metal siding with a paint job having 10 years' durability. We are trying to come up with some way to promote prefinished wood siding that will compare favorably with metal in terms of durability. I don't know whether we can do it or not.

Mr. Laughnan: I would like to add that some time ago I recommended against the use of a short oil alkyd resin primer. I expected premature cracking and, although this has not yet happened, I'm not sure that enough time has passed to prove my prediction wrong.

Mr. Hancock: There is an argument going on now between the paint industry and the fabricators who want to fit something into their own production line setup and that is why they talk in terms of minutes. Our argument is that the short oil alkyds have not been in use long enough to have been proved, and that's why we have to remember our obligation to ourselves, to the paint industry, and to the professional contractors. We could probably go to a type of long oil alkyd and get the priming job correctly done within the same time schedule, if we knew what happens to wood when it is heated to 210°F, or 220°F instead of 150°F to 170°F as is the custom. We don't know what happens to wood when it's heated to that point. It may have no effect on its paintability at all, but we have to find out.

Mr. Laughnan: We know something of what happens to wood when we heat it up to 220°F and I will say that we couldn't tolerate that temperature with those woods, such as redwood, that contain water soluble color extractors. They simply bleed out through the primer. If we aren't careful, our paint line foreman may see a board come down the line with little globules of resin on the primer surface and immediately cut back the temperature of the whole line. We have, however, learned in the past 30 days how to dry a long oil alkyd resin base primer faster than we are currently drying our short oil alkyd resin primer. We are cooperating with approximately 20 paint manufacturers, and are presently evaluating about 40 primers, more than half of which are from these companies. I know from contacts with them that they are trying to do the same thing, and they will eventually do it. However, we have actually dried a long oil alkyd resin primer, pigmented in much the same way as our present primer, within the same temperature and time limitations, and packed it under 30 lbs. psi of pressure with no sticking and without a slip sheet.

Mr. Lloyd: I find that little attention has been paid here to today's trends in design. We feel that there is a tendency to use natural products. In other words, why cover this wood up with a solid paint? Your siding looks like metal anyway. I think that more effort and research should be directed toward keeping the product in its natural state.

Mr. Laughnan: You'd find, if you checked with the more than 2,000 paint companies in existence in this country, that they have about given up trying to produce a clear surface coating that will enable you to keep the natural appearance of redwood or red cedar or other attractive wood siding. Clear coatings are very vulnerable to ultraviolet and to some of the shorter wave lengths of light. They fail by lack of adhesion; they are also sensitive to water. They do not inhibit these wave lengths of light, and the wood begins to weather under the finish, so the finish doesn't have much chance. Now, if you check with organizations like the Stanford Research Institute and others of its kind, you'll find that for about 12 years a very small percentage of wood siding has been finished in the natural. There are still many people in the redwood industry who think that a clear coating is the ultimate answer for redwood siding, but a practical clear coating doesn't exist. Actually, I doubt that more than 10% of wood siding has a natural finish today. Surveys find so little of it being used that we can't interest the paint industry in coming up with a satisfactory finish for the purpose.

Mr. Hancock: Have you talked with anybody in the last few months and received the same negative answer about outside finishes? After all these years, we in the paint industry are about ready to promote a clear finishing system for exterior use. The new sophisticated polymers, the polyurethanes, seem, with the help of the so-called ultraviolet absorbers or inhibitors, to permit the development of a practical clear exterior coating. Over the past several years we have had some exposure background with the metallic automotive finishes. The metallics were a little bit like the clear finishes until recently. They formerly failed by checking, but the use of ultraviolet inhibitors has solved this problem. Complaints about checking of automotive finishes have been extremely rare in recent years. So, we are now leaning on that same experience, and with the polyurethanes we think that we now have the durability we ought to have.

Unsigned question: What is the possibility for a completely prefinished wood material? In other words, material on which no additional coats are needed?

Mr. Laughnan: May I answer Mr. Hancock first? We've tried polyurethanes. In fact, I tried them at the Forest Products Laboratory in Madison as long as six years ago, and while I will admit there have been some marvelous steps forward with the polyurethanes, I still don't see that they are the answer to furnishing a clear, natural finish for wood. We are trying them with and without ultraviolet absorbers.

Now, to answer the second question -- we were discouraged at the results when we applied completely prefinished siding to our test houses. We may have made an unfortunate choice of the contractor who erected the siding. These people work on a piecework basis. They are used to nailing, and they resist anything new. I, myself, like the appearance of these test houses. The end result is good. I don't think there is too much of a problem except the color problem. The minute we mention complete finishing, all of our dealers go straight up in the air. I think it could be done. The problem lies in getting people used to something new.

Mr. Lloyd: I find there is less problem when the natural material is used. When you have a piece of wood and it is naturally finished, I think you have a better texture and finer quality. The minute you apply paint, you will lose the natural quality of the wood. I think that, even going back to concrete block, if more attention were to be paid to the natural characteristics of material, the manufacturers would have less problems with color. I see color books coming in by the thousands and there are thousands of different colors. This is very distracting to the architect -- everything isn't colorful in buildings. You don't go out and build a blue building -- I think there is more of a tendency towards a neutral approach, a neutral tone. Going back to the basic materials would be much better.

Mr. Nosenchuck: Mr. Parry, how do you feel about the future of completely prefinished cementitious material?

Mr. Parry: I think it has a big future. I think right now that our industry is getting most of its business from what we call "small units", such as shingles, siding shingles, or board which is erected with battens to cover up the fasteners, but I really think we are just starting in this field. If we had ways of making the board somewhat thicker, so that we could conceal fasteners on the back and do it economically, I think this would be a forward step. As far as color is concerned, our experience has been that most housing is built by developers. They build hundreds of houses and they get their styling from different colors. Houses are all very much alike. At least we find that when we have a project of 200 houses they use nine different colors of paint. That's the way they work.

Unsigned question: Thin sheets of other building materials have been fastened successfully with adhesives. What is your experience with wood and asbestos-cement?

Mr. Parry: I think it can be done with thin sheets of asbestos board applied to sheathing. You'd have to have some sort of bracing or a quick-adhering adhesive. I don't think it has been done. I don't think the industry feels safe enough about an adhesive yet, but I know that a great deal of work has been done on it and there certainly will be more. Right now, I would hate to depend entirely on an adhesive to hold a large sheet against something behind it. A combination of an adhesive and mechanical fasteners might do the job.

Mr. Laughnan: I agree with Mr. Parry. We have to look at this method of attachment, but I would be just as hesitant to recommend bonding wood siding to a structure with adhesive today as I am to recommend that our company apply a clear finish to the siding.

William Lukacs, YMCA National Building Service: Some of the thermosetting, cast-on facings have failed in high temperature conditions of over 175°F. Has this been overcome and, if so, how?

Mr. Sergovic: I don't quite understand why they failed at 175° because in our work we get the facing up to about 280° to 300° in the oven before we can get a good cure. It could be that a sustained temperature of 175° for 24 to 48 hours might cause decomposition of some kind with which I am not familiar, but at 175° I don't see how a facing could fail. I know of one instance in which failure occurred in a wall subjected to elevated temperatures. This failure was due to a bonding problem, as nearly as I could determine. The problem was basically due to the moisture content within the block. This is something that you always have to worry about. Blocks will pick up moisture any time, anywhere. If you set up a condition wherein you have a completely sealed area in the wall and there is moisture behind it, then you have a condition in which the moisture creates a pressure and the face can blow off. If this is the type of failure that you are talking about, this could have happened, but you can't blame that on the facing material. You have to blame it on the conditons of construction, or something of that nature.

Mr. E. R. Schauffele, The Atlantic Refining Co.: Ease of cleaning of the walls is one of the advantages of smooth-coated block. Is anything being done to coat the mortar so that this cleaning can be done even more easily?

Mr. Sergovic: Yes, there are a great many things being done with mortar. One approach is to coat the mortar joint completely after the wall is erected. Another approach is to use something to cover the mortar, which we call pointing. In other words, as the wall goes up, some of the mortar between the blocks is scraped out and a gap of 1/4" or 1/2" if left. This is called raking out the joint. After the wall is erected the joint is filled with some impervious substance. There are epoxy combinations now being used for the mortar joints which are quite good. From the standpoint of the mason they have some problems connected with them because he has pot life to worry about, but once he applies them, they are quite impervious and are very easy to clean. Basically, these provide a very sanitary joint, very much like the facing.

J. W. Brock, Canadian Industries, Ltd.: Do you find that the coatings used must have a certain definite permeability to moisture vapor in order to avoid moisture blistering failures?

Mr. Parry: No, we do not. The coatings are not absolutely tight. Shingles always have air space around the edges so we never have had any trouble with blistering. I would say that the main problem with moisture would be if you had a material which did not have good adhesion or good wet adhesion. You can put a properly coated shingle in a tub of water or in a blister box and it doesn't blister. I think the problems of condensation within the house have to be corrected by construction, because any material which is painted a number of times will have a more or less tight film. With shingles or boards there is usually enough space around the edges so the water can get out.

P. C. Herzog, Glidden Co.: Is the dry process the cause of inverted, cone-shaped "pops" (pop-outs of coiled fibers) encountered by the asbestos-cement shingle industry?

Mr. Parry: I don't know what cone-shaped 'pops" are. The dry process is simply a way of getting water into a sheet. You make a dry mix and wet it afterwards.

E. D. Martin, Architect: Is anything being done to develop porcelain enamel glazes on block by using low temperature glazes?

Mr. Sergovic: Yes. I am not a ceramic engineer, but to my mind at least, porcelain glazes and ceramic glazes are pretty much in the same category. The approach being made now by the people interested in glazing a concrete block with a ceramic thread or glaze is in the low temperature field. It would have to be, because I don't think that the concrete block, as such, could stand the 1500°F or 1600°F temperature necessary to fire a ceramic frit. There is another possibility. That is a block that's made from clay rather than from a concrete aggregate. If and when such a block becomes available, we will be able to put on true ceramic frits rather than these low temperature glazes.

T. F. Harland, Pittsburgh Interlock Tile: How have you handled the vertical joint problem on your experimental factory prefinished wood siding?

Mr. Laughnan: If what is meant by "vertical joint problem" is the butt joint, we haven't made much progress. What we have done up to this point is simply butt the siding and hang it, and with both hangers we get fairly good alignment. This wasn't always true. We have had a little misalignment, but this is taken care of by nailing between the butt joints. Actually, we are considering a method of end-matching the siding so that we will not have any trouble with alignment between individual boards. I believe this is the direction in which we should be going.

W. R. Sweet, Rohm & Haas Co.: Are edges and ends of siding adequately protected against weathering by factory prime coating followed by finish coating in the field? How severe is the problem of film rupture produced by cutting and nailing during construction?

Mr. Laughnan: We coat the ends of our pieces of siding in the plant while they are still in the stack. They are tightly piled, and we spray the ends. This is end wood grain, of course, and there is excessive absorption. In my opinion our protective coat is not good enough, but you have to balance this with what happens out in the field. The carpenter saws these pieces of siding to match out on 16" centers, and we persist in making them in 2' increments. That means they come together one time in four feet. This, I think, is all the incentive we need to end-match our siding. We could reduce the labor cost involved by a terrific amount. I've yet to convince all the people in our company that this is right.

Mr. Nosenchuk: You mentioned prefinished redwood siding and shingles. Is the redwood lumber available as a stock item and, if so, is the appearance essentially that of natural redwood?

Mr. Laughnan: I don't know that I understand that question. This year we will have applied an opaque primer to about four million feet of redwood siding, but about nine million feet of siding will have gone through our paintline, the bulk of that receiving only a water repellant preservative. To a lesser extent, a couple of colored finishes, not very heavily pigmented, are applied to it. We still sell completely untreated and unprimed redwood siding in appreciably large volumes.

James A. Scott, Raybestos-Manhattan, Inc.: Please comment on the economic feasibility of prefinishing concrete block with an exterior waterproof coating and an interior decorative finish, and what, in your view, are the preferred types of finishes for these applications?

Mr. Sergovic: What we are trying to do is to put a facing on the inside, use the block as is on the outside, and keep the water from coming in. There is no problem with the inside facing. As far as the outside is concerned, about the only water repellant work that has been done has been with silicones. Apparently, the silicones migrate. They do a job for a while, but eventually you either re-silicone the surface, or the water will start coming through.

Mr. Hancock: As a matter of information, there is a new treatment coming into vogue that does two things. First, it smooths up rough block and, second, it does a fairly effective job of sealing. This is a mixture of portland cement and latex. As a matter of fact, I think there is a Federal specification covering this. We are experiencing more and more demand for that type of compound. But, to get back to paint, all paint does in rough block is coat the void: it never fills anything. I don't know of anything that does, including silicon.

Mr. Lloyd: The thing that bothers me about this question is that we are discussing one block that will be the total thickness of the wall. This isn't normally good practice. We have been designing cavity walls. What we are doing today on most walls is to let the water come in, but provide a place where it can get out.

THE ECONOMICS OF PREFINISHING

Session Chairman -- William Lukacs
Director of Research
Buildings and Furnishings Service
National Council of the YMCA of the USA

Economics of Prefinished Components in Industrial Construction

By John W. Baker*, Coatings Chemist,
Butler Manufacturing Co.

Many advantages have been gained by the builder of commercial and industrial structures in the past five years due to the great advances made in the factory prefinishing of building components. Manufacturers have developed the necessary techniques to factory finish many different types of materials, giving architects a greater selection, and making it possible for the correct material to be used for each individual application. The factory finishing of various metals has increased their durability and beauty and, at the same time, has contributed to the lowering of construction costs.

The people connected with the prefinishing of components have become less inclined to refer to these coatings as "paint jobs", as they realize the increased decorative and protective properties now being attained. The present trends toward better surface cleaning, applications of crystalline phosphate or amorphous chromate surface treatments, and the use of heat-converting types of finishes have prolonged the life of the coatings and increased the resulting economies to the point where the field application of finishes no longer compares favorably with the factory applied coating.

Basis for Comparison

With today's trend toward upgrading the appearance of industrial structures to blend with their improved surroundings, as in the case of industrial parks, it is becoming general practice to group commercial and industrial structures in the same category of buildings. The materials available to the industrial builder can readily be dressed up to meet the demands of commercial buildings with slight changes in detail and increased emphasis on the aesthetics of the individual structure.

In making comparisons, we must take into consideration what can be done to a material when it is factory prefinished, as compared to the standard practices encountered in the field application of coatings. Such factors as surface preparation, application methods, and controlled conditions play an important part in the expected life span of the coatings and thus in future maintenance costs, and must therefore be carefully weighed. Against these factors we must consider original price, availability and individuality.

Due to the complexities of industrial buildings, it is necessary to deviate from the usual cost per cubic foot of building to the in-place cost per square foot of wall or roof paneling. It is also necessary to use costs that have been averaged on a nation-wide basis because of labor wage differences, application methods, rates of production and many other variables that affect the cost of the finished item. The costs mentioned in this paper are carefully weighed averages of today's market costs and, wherever possible, have been calculated from costs obtained from large and small jobs completed in all sections of the country. These costs have been obtained from over 30 actual field painting jobs completed or bid this past year, and from surveyed or actual production-line costs covering several different finishing methods. Costs will be low for some sections of the country and certain methods of application, and high for others, but all of the costs are considered to be realistic comparative figures.

---

*BAKER, JOHN W., B. S., St. Ambrose College; Member, National Assn. of Corrosion Engineers. Butler Manufacturing Co. is a Member of BRI.

Structural Components

Structural components prefinished at the point of fabrication are not gaining in popularity as rapidly as is the prefinishing of other building components. This is mainly due to the fact that completely finished structural components are costly to ship and easily damaged. Therefore, the cost of shipping and field touchup of these prefinished units might outweigh the cost of field paint after erection.

One large industry that is approaching this problem, and requesting that structural components at least be semi-finished, is the chemical industry. The demand for chemical-and fume-resisting coatings increases yearly, and experience in the methods and economics of semi-finishing versus site-finishing is being gained rapidly.

To give a brief example of the costs encountered in preparing surfaces to withstand chemicals versus regular shop coating, we can determine the following costs for the combined factory and site-finishing.

TABLE I
Cost per Ton for Combined Factory and Site-finishing of Steel

Chemical Resisting Finish		Regular Shop Coat & Decorative Finish	
Blasting	$20.00*	Cleaning	$ 2.40*
Cleaning	2.40		
Shop Priming		Shop Priming	
Material	8.00	Material	4.00
Labor	1.76	Labor	.88
Field Coating (two coats)		Field Coating (one coat)	
Material	24.00	Material	8.50
Labor	16.16	Labor	8.13
Total	$72.32	Total	$23.91

*Figuring an average of 2 1/2 lbs. of steel per square foot of surface area over the total structure.

These figures show the tremendous differences in costs that can be encountered in preparing steel to withstand severe corrosive atmospheres.

Prefinished Wall Components

The best way to establish the economic differences between factory prefinishing and field application is to take a close look at the costs involved in both types of application, and determine just why each is priced at a certain amount. We can start by looking at the costs involved in the factory finishing of either aluminum or galvanized siding on a large scale production. These costs, averaged for automatic spray and roller coating, would be as follows:

TABLE II

Average Costs for Factory Finishing of Siding Per 100 Sq. Ft.

	Direct Costs	Indirect Costs
Vinyl Coatings (exterior 1 mil, interior .75 mil)	$ 2.01	---
Chemical Coatings (phosphate or chromate)	.50	---
Labor	.11	---
Amortization of equipment (Avg. 10 year life)	---	2.34
Material handling, overhead, & additional cost for misc. coated accessories, etc.	---	3.02
Equipment repairs and improvements	.01	---
Miscellaneous (steam, air, etc.)	.01	---
	$ 2.64	$ 5.36
Total factory-produced cost	$ 8.00	

Costs for field application differ because of the substitution of manual labor for expensive equipment. In a recent study made by one of the chemical companies, it was found that a minimum of two coats is required if no preliminary phosphate treatment is given to the zinc coating of galvanized steel. This is also good practice when coating aluminum. Therefore, we would have to expand these costs to include this expense when considering coating these metals in the field.

TABLE III
Average Costs for Field Finishing of Siding Per 100 Sq. Ft.

	One Coat	Two Coats
Cleaning (solvent wiping or acid detergent)	$ 3.38	$ 3.38
Coating		
Primer (MIL-C-15328A or MIL-P-26915)		.66
Enamel (alkyds at contractors' prices at 1.5 mils)	1.20	1.20
Labor	3.38	6.76
Equipment & Overhead	1.44	2.66
Total field applied cost	$ 9.40	$14.66

On-site erection costs of the prefinished and field finished materials have proved to be almost equal. Extra care must be exercised in handling the prepainted sheets, but this expense is largely offset by the increased corrosion resistance of the sheets. The labor cost necessary to keep the unpainted, bundled sheets water-free has, in most cases, nearly matched the cost of additional care taken with the prepainted sheets.

Uncoated galvanized sheeting can lose up to 1% of its weight per week when immersed in water. One can readily understand, therefore, the extra care that must be taken on the job site with tightly-wrapped bundles of unpainted sheeting. Uncoated aluminum also tends to stain when exposed to trapped water, and it is the labor used to prevent this that offsets the handling and touch-up costs of coated sheeting.

The comparative economies are based on the theoretical erosion rates. However, the cost of finishing cement block must be compared on a slightly different basis. Erosion rates are difficult to measure on the irregular surface of a block or tile. Therefore, it is necessary to assume that the erosion rate on masonry surfaces will be comparable to that of metallic surfaces. The costs involved should remain similar to those for field coating of siding, with the exception of labor, which reportedly increases approximately 20% to 30% depending on the texture of the block. This gives us a cost for field coating as follows:

TABLE IV
Average Cost for Field Finishing of Masonry Per 100 Sq. Ft.

	One Coat	Two Coats
Coatings	$ 1.20	$ 2.40
Preparation	4.22	4.22
Labor	4.22	8.44
Equipment & Overhead	2.11	3.17
Total field applied cost	$11.75	$18.23

These figures enable us to compare the extended cost of coatings per year. We started out with the factory cost of vinyl at $8.00 per 100 sq. ft., with an orginal film thickness of 1.0 mils. The field applied coating of primer and alkyd enamel on metallic siding and concrete block, with an enamel film thickness of 1.5 mils and costs of $14.66 and $18.23 respectively per 100 sq. ft. gives us a direct comparison.

Taking into consideration the erosion rates established at the present time for the different materials, we can arrive at an extended cost per year over a 20-year period. Information on erosion rates available from suppliers shows:

	First Year	Per Year After Initial Year
House Paints	.5 mils	.27 mils
Alkyd Enamel	.11	.1
Amine Alkyd	.066	.065
Vinyl Enamel	.029	.027

It is generally agreed that wall surfaces will need recoating for protective purposes when the coatings reach about .6 mil film thickness, assuming that the original coating was applied at a uniform thickness. (See Figure 1). The uniformity of the coating deposited has a great effect on the ultimate life of the coating, and this uniformity can greatly change the ultimate economics of the coating.

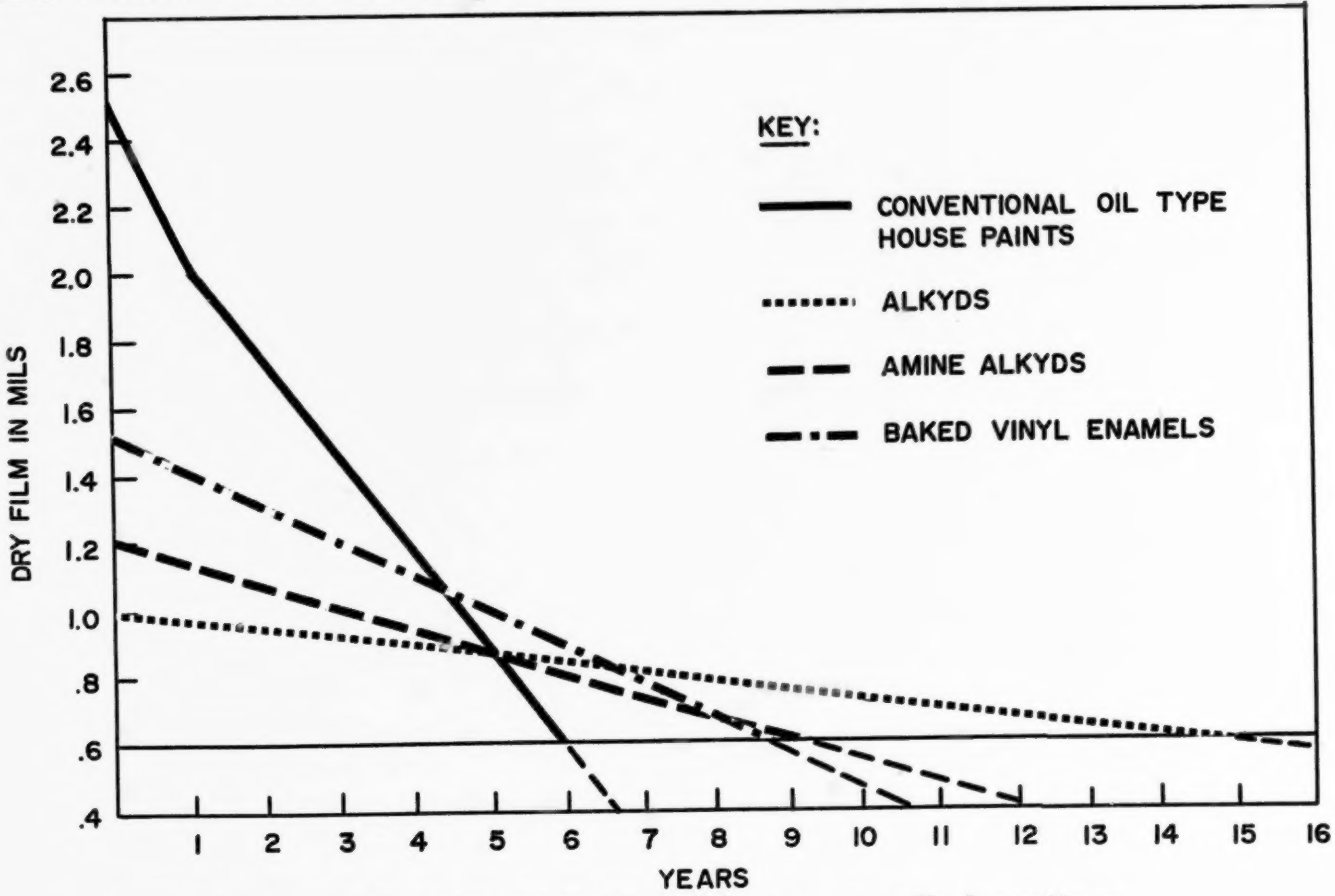


Figure 1. Erosion rates of field and factory applied coatings.

Thus, the theoretical cost per year of the three systems is shown in Table V.

TABLE V
Comparative Costs of Three Systems

	Coatings Factory Applied (Metallic Siding)	Coatings Field Applied (Metallic Siding)	Coatings Field Applied (Concrete Block)
Original cost per 100 sq. ft.	$ 8.00	$14.66	$18.23
Recoated at 9 years	---	9.40	11.75
Recoated at 14 years	9.40	---	---
Recoated at 18 years	---	9.40	11.75
Total cost for first 20 years	$17.40	$33.46	$41.73
Cost per 100 sq. ft. per year for 20 years	.87	1.67	2.08

This, of course, presents a theoretical cost for each system, but there is such a variety of exposure conditions that those to be encountered by each individual structure must be considered when trying to determine the ultimate cost. Some buildings in heavily industrial atmospheres will have an ultimate cost in excess of double the figure shown above, while others will have only a fraction of that cost. Field experience in each area will dictate the direction to be taken when estimating the cost for a given area or location. However, we believe that the given ratio of refinishing time will remain the same. If the factory finished material requires refinishing in a shorter period of time than that shown, due to local conditions, the field applied coatings will also need recoating in a proportionately shorter time.

Roofing

The approach to the economics of prefinished metallic roofing can be varied to include the ultimate cost of the entire roof system, finishing and maintenance.

The chart on the following page (Table VI) compares five roof systems varying in initial price, from original construction over a 20-year period, including finishing and maintenance cost.

This provides a direct comparison of the average roof systems offered to the industrial builder. Insurance rates, insulation and design limitations have not been taken into account in this comparison, since these items vary considerably with the building area or personal preference.

TABLE VI
Comparison of Five Roof Systems

Roof Type	Commercial Corrugated Field Painted	Custom Ribbed Field Painted	Custom Ribbed Factory Finished Both Sides	Custom Ribbed Factory Finished Both Sides	Built - Up Roofing
Material	26 Ga. Galv.	26 Ga. Galv.	26 Ga. Galv.	.032 Alum.	Gypsum Sub Purlins, Foam Bd. 5-ply Roof
1. Initial Costs					
Installed Cost	$26.50	$39.20	$47.32	$62.52	$69.00
Fastener*	3.00	6.26	8.42	8.42	---
Addn'l for Increased Structural Loading	---	---	---	---	14.00
Field Coating	10.32	10.32	---	---	---
Total Initial Cost of Panel	$39.82	$55.78	$55.74	$70.94	$83.00
11. Resurfacing Costs**					
9 year	$ 8.64	$ 8.64	$ ---	$ ---	$ ---
10 year	---	---	---	---	5.00
11 year	---	---	8.64	8.64	---
18 year	8.64	8.64	---	---	---
20 year	---	---	---	---	5.00
Total Cost of Resurfacing	$17.28	$17.28	$ 8.64	$ 8.64	$10.00
Total	$57.10	$73.06	$64.38	$79.58	$93.00

*Metallic roofs are shown with the cost of the usual fastener system used with each particular type of paneling.

**Coating costs shown are lower than costs for walls, due to the elimination of the need for use of scaffolds or ladders.

Miscellaneous Components

One of the aspects of prefinishing building components still creating difficulties for the manufacturer is the finishing of the miscellaneous components; the windows, doors, gutters, flashing, and ventilators. The general upgrading of product lines has included more colors and more decorative flashing, and a more complete finishing of the building parts. Before the advent of the prefinished component, the manufacturer only needed to have one complete stock of miscellaneous parts on hand for shipment. He could set up his tooling for the most economical run of each part, and warehouse them until the time of shipment. With the expansion of product lines, it was necessary to find an economical way to finish these multitudes of parts in a variety of colors, otherwise the manufacturer would have had to multiply his warehouse space and the money tied up in inventories by the number of colors added. This has created a problem in that production lines cannot be set up to finish economically parts ranging in size from 6" to 60' in length, and ranging in shape from ribbed siding panels to 3' wide ventilators.

To make an actual comparison between the cost of factory finishing these components and the cost of field painting would be misleading, due to the many different methods used by the various suppliers. These methods range all the way from completely finishing components to match the siding color, to using one harmonious color to match any siding color, or supplying flat finished sheet so that the parts may be field fabricated.

One field finished lineal foot of trim, whether it is window stripping or gutter, is sometimes estimated at the same price as a square foot of siding area. This same general rule would hold fairly well for the factory finishing of the corresponding parts. Additional labor for handling and waste of finishing materials increase the cost over that of the finished siding. However, the cost of factory coating the miscellaneous components is usually figured into a bulk cost for the coated siding and, therefore, it would be misleading to give a direct comparison of the factory and field coated costs for these particular items.

Tanks and Storage Equipment

Today's trend toward bulk storage of many materials is increasing the need for the manufacturer to produce storage and handling equipment that is more resistant and durable. Some of the many products being handled today in bulk storage tanks are cement, plastic pellets, flour, wine, fertilizer, chemicals, and cattle feed. Tanks for this purpose must either be factory finished or field finished with chemical resisting or sanitary linings.

The particular requirements of the type of product to be stored make a tremendous difference in the finished cost of the coated storage tanks. Film thicknesses can vary from 2 to 14 mils. Coatings could be vinyls, epoxies, urethanes, vitrious enamels, or dozens of other costly compounds. Therefore, the economics of whether to use a factory coated or field coated tank is based on the particular requirements of each installation. It is less expensive to grit-blast and coat a sectionalized tank on a production line basis; however, the savings might in some cases be offset by the shipping and handling expenses incurred. To develop a comprehensive, truly comparative cost figure for such installations would require a great deal of time and effort. Therefore, I believe that this subject should be thoroughly covered in a future conference, rather than considered lightly at this time.

Panel Discussion

Moderator: J. W. Brock, Technical Planning Manager - Plants Division, Canadian Industries, Ltd.

Panel Members:

Mr. Baker plus
Harold J. Rosen, Associate, Kelly and Gruzen, Architects
R. P. Ericson, Assistant Technical Director, Paint Division Pittsburgh Plate Glass Company
Ray N. Elvart, President, Ray N. Elvart and Company
Charles E. Freeland, Indiana Council of the Painting and Decorating Contractors of America
George O. Lloyd, Jr., Partner, Perry, Shaw, Hepburn and Dean, Architects
William Lukacs, Session Chairman, Director of Research Buildings and Furnishings Service, National Council of the YMCA of the USA

Mr. Lukacs: We are very disappointed that we have no paper for this conference presenting the point of view of one of the most dynamic segments of the construction team in America, the home builders. America is famous for its large percentage of mass and custom-built, single-family homes, all privately owned. We are famous for planning large-scale communities of partially or wholly prefabricated homes. Why then, have four prominent members of the home building industry first accepted and later refused our invitation to present in detail the economics of prefinished exterior components in the residential field? Have they inadvertently stumbled upon a secret of success and profit through prefinishing which the individuals were unwilling to disclose to such a learned group as ours?

All of us know that prefinished asbestos siding and various other items are commonplace, are used every day by every one of these builders. We've heard of asbestos-cement, aluminum, stainless steel and other materials, readily available in an excellent range of colors. Flat panels, window and door units in these materials are also commonly available. We hope a member of the audience for this discussion will have the courage to take up the challenge and give us some pointers on the economics of prefinished exterior building components which we seek. What is your cost for the prefinished items which I have mentioned vs. the cost of finishing after erection? These data should cover such properly weighted factors as the cost per square foot or component per year to failure;

cost of field refinishing including touch-up; over-all comparative costs, including overhead, profit, etc., due to special equipment and special handling; possible cost involved in stocking a selection of colors to satisfy a variety of buyers, and similar related costs.

H. Zahrndt, National Starch & Chemical Corp.: The number of coats that must be applied in on-site painting greatly affects the cost. Do you see any prospect of a truly one-coat finish for field application?

Mr. Ericson: I would be very pessimistic about a one-coat system for any porous substrate such as wood or similar material, because you do have to have a primer to insure proper holdout of a top coat for uniformity of the final appearance. Another thing: field application is not closely controlled with respect to film thickness. There are, inevitably, problems of the substrate showing through thin areas and skips. I am afraid that one coat is skimpy in many cases.

Mr. Brock: I think a one-coat finish for field application on vertical surfaces is still some distance away.

C. O. Hutchinson, The Glidden Company: Was the cost per 100 sq. ft. based on sq. ft. coated, or on sq. ft. of metal?

Mr. Brock: In other words, are you talking about both sides or just the cost of coating one side?

Mr. Baker: We coat both sides of all sheets. Mainly, it's for our own advantage. We find that we cannot economically ship uncoated sheets, or sheets which are coated on only one side, because of the protection needed to prevent water damage in transit. Therefore, the costs I gave were for both sides coated. However, the re-coating cost was for one side only.

George R. Hoover, Armco Steel Corp.: Your phosphatizing cost seems very high. Can you explain in more detail?

A. W. Slocum, De Soto Chemical Coatings, Inc.: You have indicated that on-site painting costs $24 for material and $16 for labor. Experience indicates that material accounts for 20% and labor 80%. How do you reconcile your figures?

Mr. Brock: There are a number of these questions, and I think the best thing that we might do here is quote some sources of cost information.

Mr. Baker: We don't have the wealth of experience that would be needed to do a meticulous job on this. We took the average cost of about 50 buildings painted this summer. They are located in all parts of the country and they range in size from 500 sq. ft. to thousands of sq. ft. of siding. We took these average costs and broke them down into the number of coats applied. We took the cleaning cost, where cleaning was involved, and averaged all these costs to come up with an average figure. These costs varied tremendously. We had some buildings we could paint for three cents per sq. ft. including cleaning, and others cost $1.00 per sq. ft., but the $1.00 figure was the exception. Based on this, the average cost of a one-coat job was 9.4 cents per sq. ft. The cost of phosphatizing does seem high if we are talking about strip coating where there is no carryover and no waste. Our phosphate costs include strip coating and miscellaneous parts. I would like to know how you coat a six inch gutter without carryover and without a lot of waste? Also we have encountered tremendous differences in steel. We've had occasions where we had to greatly increase our cost to get it clean. On other occasions, we've had to increase our cost to get a good phosphate treatment. At other times our costs were considerably reduced. When you're dealing with odd-shaped parts, where you don't have a natural drainage, a situation which we try to design against, you have a tremendous amount of carryover and you can use a tremendous amount of chemicals. But the costs were average costs for both strip and odd-shaped parts.

S. C. Frye, Bethlehem Steel Co.: Please reconcile your figure of eight cents per sq. ft. for coating with the figure of two cents per sq. ft. which was quoted in another paper.

Mr. Baker: Eight cents includes the cost of coating both sides. This means materials, labor, overhead and handling of fabricated parts, plus the cost of waste that may be found in the coil. Sometimes you have scrap all the way through a coil. By the time a coil is actually roll formed into panels, the mill cost will be much higher than two cents per sq. ft.

Mr. Elvart: I wonder if these costs include the additional shipping costs, handling costs, and packaging costs?

Mr. Baker: No. Actually, at times, our shipping costs and costs of protecting the coatings are more than the cost of the painting.

Mr. Frye: In your experience, Mr. Elvart, how do costs of field finishing metal compare with those given by Mr. Baker?

Mr. Elvart: I don't think I can argue with Mr. Baker's costs too much, because he used a generalization and I can't argue with that. Costs will range from two cents to $1.00 per sq. ft. depending on the availability of the surface, the conditions surrounding the building, the design, etc.

Mr. Brock: This is true, but he did give one particular case in which the cleaning was done, and the specification primer and a conventional top coat were applied, under normal environmental conditions in the field.

Mr. Elvart: I don't have too much experience with this but it would seem to me that the field applications would probably be cheaper although not as adequate. However, another factor to consider would be the touch-up of damage in the field. You certainly can't touch up rusty edges and damaged spots with the same process that was used for prefinishing the sheets, so there would be an inadequate film at the point of touch-up.

Unsigned Question: How does the cost of touching up defects that occur in the field affect the cost of the prefinishing coating?

Mr. Baker: These costs are fairly well balanced out. Our builders have found that now, since they are used to handling these buildings, there is no more time involved in putting up a prepainted sheet or roof than there used to be for an unpainted sheet. Originally, this was not so. It took a great deal of education and there was a great deal of complaining on everybody's part before things got to the point that their men could handle these sheets. I have mentioned the care that must be exercised with unpainted sheeting, galvanized or aluminum, on the job site. Actually, they have claimed that it costs more to protect those uncoated sheets than it does to install the fully coated sheet on the job site.

Mr. Brock: You don't have much trouble with soiling which requires touch-up?

Mr. Baker: Not so far.

Mr. Brock: Mr. Lukacs mentioned that we had nobody from the home building industry on the panel, but one large builder did write me a letter. I am going to read one paragraph at this time because he says:

> "Our industry would be grateful for material that could be fabricated into wall panels without workmen damaging the finished appearance. We have experimented with some finished goods which had been acceptable when delivered, but after our workmen fabricated this material, they spoiled the finish to such an extent that many times, after the house was delivered on the site, the house had to be repainted. The extra cost of prefinishing the material was lost, because the work had to be done by our builders again. We instructed our workmen to work with white gloves but, after a few hours, these clean white gloves became soiled and the finish of the material was spoiled. A finished piece of goods that could be wiped clean after fabrication would be of great value to us."

R. F. Wint, Hercules Powder Co.: On-site finishing is very dependent on weather conditions. Can anyone on the panel say how big a cost factor this can be and what savings can sometimes be made by the use of prefinished components?

Mr. Freeland: Weather is a factor in any type of construction, regardless of whether you are using a prefinished component or a field finished component. I can't see that there is any saving in cost just because the unit is prefinished. Certainly, you might erect a building a little faster, but we still must face the fact that, once the building is erected, the painter still has to go back and do the touching up. The weather naturally interrupts construction. The only advantage of prefinishing is that you can erect panels during inclement weather but, eventually, you have to come back and do the touch-up.

Mr. Ericson: I think there is a substantial saving possible in prefinishing because, particularly with metals, you can take a simple shape, such as a continuous coil of metal, and factory coat it on both sides, under controlled conditions. This can then be used to form the desired siding shapes. The actual finishing costs are substantially less than they would be if the same metal were formed and used to erect odd-shaped buildings with dormers, glass, and perhaps brick which would have to be masked off during the much less efficient field painting operation. We know that in industrial finishing, which has nothing to do with buildings themselves, the simpler the shape, the lower the finishing cost. For example, with a complex shape like a file cabinet, if the same metal could be painted as a flat sheet and then formed into the finished product rather than to spray it or otherwise coat it after assembly, it would be possible to save a considerable amount of money. This is where the economic advantages are. So, as far as touch-up in the field goes, the aluminum people have learned that they had to have special siding applicators and they had to teach them the proper methods to erect prefinished siding. As a result, we have more sophisticated erectors than we formerly did. The same changes will have to take place in other areas where prefinished materials are assembled.

Mr. Lloyd: There is another factor that has been lost in this discussion. After all, there is the general contractor who, any time that he can speed up his work, makes a major saving in labor cost.

R. F. Wint, Hercules Powder Co.: One of the papers referred to the use of strippable coatings to protect factory finished components until after installation. Can any one say what such removable coatings would add to the cost, and the extent of the savings that should result?

Mr. Ericson: I would guess that your material cost will approximate that of the permanent finish.

Mr. Freeland: We've had experience with strippable coatings. The cost of the strippable coating is much less than that of a finished coat, because the mil thickness is less. Actually, strippable coatings do not necessarily protect prefinished components. Quite frequently, we find that electrical cabinets, which usually come with strippable coatings, are damaged during construction. The least bit of abrasion skins the strippable coating back and, invariably, we are called on either to touch-up or repaint those prefinished components. Although we are in the strippable coatings field, we don't feel that they are doing the job that the manufacturer would like to have us believe.

Mr. Lukacs: In writing a specification on exterior finishing, is it possible to provide for accurate cost comparisons between prefinished and site finished components? Have you had any such actual costing experience?

Mr. Rosen: I haven't had any of that particular experience, but you could very well set up an alternate in your specification and take bids specifically on prefinishing the material and erecting it, or on field application of coatings, and obtain true costs that way.

Mr. Freeland: Mr. Brock, is the comparison asked for that of the difference in cost of a prefinished component and a field finished component?

Mr. Brock: Yes.

Mr. Freeland: We find, in this job that we are doing, that our cost has been highly increased. We prefinish the material at the mill. By the time it gets down to the job and gets erected, we practically have to do the job over.

Mr. Brock: I think we will all agree that this will vary a great deal depending on the particular circumstances of the job.

Mr. Ericson: What is the nature of most of the prefinished materials you are referring to? Are these wood, or metal, or something else?

Mr. Freeland: In this particular case I am referring to wood. I don't have too much to say about metal other than what I mentioned before -- the touch-up, and sometimes refinishing of metal cabinets in schools, and things of that nature.

Mr. Lukacs: We have run exact cost comparisons, not on wood but on other types of materials, one of the principal materials being a ceramic prefinished asbestos-cement panel. This was compared to the same asbestos-cement panel finished on the job site, and even though the initial cost of the prefinished panel was substantially higher than the plain panel, including the painting, there was a net saving of approximately 10% to 15% with the prefinished panel in place. This panel now has been in place eight or nine years and still is as beautiful as the day it was put in. It has been washed repeatedly, and it has received abuse. The field applied paint on panels of the same base material failed in from four to six years, and they were not as attractive and not as carefully finished, although the workmanship on the job was good.

Mr. Baker: On this matter of damage to components, we find that we have to make large runs of any particular part in order to enable us to economically provide the crates or cartons needed for adequate protection in shipment. Our carpenter shop is set up to produce the necessary cartons correctly and economically. Our material handlers get used to one particular part, so that they know how it is to be packed, the precautions they have to take, etc. That makes a tremendous difference. We spend a great deal of time and a lot of money, initially, to develop a carton or container, plus the packing that will be needed. I think there has been a lot done in this area, to help protect the prefinished units. When it was first started, everybody just threw the product in a box and let it go. That is not enough. The cartons have to be designed and engineered correctly for shipment, because some freight yards can do extensive damage to the contents of a railroad car.

G. P. Myers, Pittsburgh Plate Glass Co.: You did not include erosion rate data on acrylic coatings. Since acrylic coatings are widely used on building components they should be included. Is there a particular reason for omitting them?

Mr. Baker: There were several paint companies which provided information on erosion rates of the materials that I mentioned: the conventional oil types, amine alkyds, alkyds, vinyls, etc. There was general agreement between several suppliers on what these erosion rates are. There is a slight range, but not enough to matter. However, I purposely did not include acrylics because the range is so widespread that I didn't think I should use it.

Mr. Ericson: The difference in reported erosion rates to which Mr. Baker refers is undoubtedly due to the fact that the name, acrylic, has been used to describe a wide range of products, some of which are essentially single polymers, and some physical mixtures or blends with modifiers. In the latter, the amount of acrylic containing polymer may vary considerably. We've been making erosion rate studies of our thermosetting acrylics since they were introduced some four years ago, and the erosion rates are so insignificant now that we think it will be a few years before we can say what they really are. Right now, they appear to be indistinguishable from good vinyls.

Mr. Brock: I agree with Mr. Ericson's findings that thermosetting acrylics, the best ones, have long-time durability and low erosion rates.

Mr. Freeland: In Mr. Baker's paper, he compares the erosion rate for a factory applied finish, which is a vinyl, against a lead and oil finish applied in the field. I think it is a mistake to do this, because today the paint manufacturers have made the same type of vinyl materials available to the paint contractor for application in the field. Today we can spray-apply these vinyls in the field the same as they can in the plant, and put the same type of coating on the material. The reason that this is not done lies in the fact that the manufacturers quite often bypass the architiect, and sell direct to the owner. The owner does not know what type of material to specify for field application.

Mr. Baker: Actually we like to see a spray-applied vinyl on any recoating job, and we will furnish the vinyl if they cannot get it locally. However, we have come across situations where the vinyls cannot be brushed adequately enough to give them a good appearance, and in many areas painters aren't allowed to use spraying. For instance, there might be a white building next to a red brick building and they would be afraid to use spray equipment. So, I did compare it, not with the lead and oil or oil types, but with the air-dry alkyds which we find to be the next best. If someone has a better coating we'd be glad to get it, but in a lot of cases the contractor cannot spray it.

Mr. Freeland: I think that situation has been remedied. There is no area that I know of today where we are restricted in spraying by labor.

Mr. Baker: I didn't mean only by labor but by proximity, by adjacent buildings, by the danger to cars, etc.

Mr. Freeland: But today our manufacturers have given us an airless spray, so that this is no longer a problem. We are in the process of spraying a building right next to a brick structure that has a colored finish on it, and with airless spray we don't have the overspray to worry about, today.

Mr. Baker: I agree, but I wish it was more acceptable across the country. In a lot of places, you suggest airless spray and people do not know what you are talking about.

Mr. Rosen: Often there is no communication between manufacturers and architects. If the architect who designed Mr. Freeland's building had been aware that there were vinyl paints that could be spray-applied in the field, I am sure that he would have considered them, and perhaps used them. But there, again, is the lack of communication between the manufacturer and the architect, to educate him and let him know what is going on.

J. C. White, Inland Steel Products Co.: Why do architects seem to resist the use of the prefinished exterior building components? Is the architect today prepared to sacrifice some freedom in his design for the economies of prefinished building components?

Mr. Rosen: I don't think the architect resists the use of prefinished materials. He evaluates the different materials that he thinks he can use for a particular building, and decides on that material which, in his judgment, satisfies the particular needs. If it's a prefinished material, he will use it provided it can do the job.

Mr. Lloyd: Naturally, there are many problems involved in buildings and many different points of design, but our average client today is economy-minded, plus the fact that he is also maintenance-minded. We have just recently finished a number of dormitories for universities, and we have used many of the prefinished materials, particularly the doors and door frames, both exterior and interior. We find that the finishes stand up much better. We've had no problems with these units on the job, as far as protection is concerned, and we favor them very much. We feel there is a saving in these products too, which is not apparent. You really can't compare what it will cost in the field with what is done by the manufacturer, because the manufacturer makes doors, windows or other items for which cost comparisons are very difficult.

Conference Summary—Future Trends and Needed Research

By Luigi A. Contini,* Manager, Market Research and Development
Plastics Division, Monsanto Chemical Company

The papers and discussions assembled here have supplied a wealth of information about the variety of prefinished products, the technical aspects of prefinishing, and the extent to which prefinishing of substrates has become customary in the construction industry. This paper will deal with trends in prefinishing, and the effects that these trends will have on research requirements. Such forecasting is doubly difficult because of the apparent confusion and diversity of architectural design; and second because of the great variety of materials which can be used for exterior finishes.

Today, a major problem is our failure to discipline ourselves in the interest of making effective use of the industrialized process. We can do an almost limitless number of things by using new processes and new materials. We have a bewildering choice of methods and materials with which to do almost any job. We can, as our engineers put it, correct almost any design mistake with technology. But, unless we can create an atmosphere in which we can understand one another's needs, the future of prefinished components, including those under discussion here, will be severely limited. Therefore, in discussing the future of coatings and their relationship to prefinishing, we must review the situation as it exists today.

Prefinishing of exterior components involves the transfer, from the field to the shop, of the function of providing a structural exterior part as well as a decorative surface. Because field conditions are more uncertain than those in the shop, costs of labor are higher in the field. The time during which a building site is tied up by construction is unproductive and expensive, so a major trend has developed in all segments of the construction industry. This trend is toward a greater amount of shop fabrication of components. The demand for efficiency and reduced costs has caused the manufacture of prefinished components to become an accepted practice. At the same, time, this has broadened the range of materials which can be used as finishes, because of the flexibility of manufacturing processes compared with the limitations of on-site finishing.

Exterior walls have traditionally performed many varied functions in building design. These are listed on the following page.

---

*CONTINI, LUIGI A., B. S. in Mechanical Engineering, U. S. Merchant Marine Academy, B. S. in Physics, St. Johns University; Member, American Marketing Assn., Design Directors in Industry, Packaging Institute, Society of Plastics Engineers, Society of the Plastics Industry. Monsanto Chemical Co. is a Member of BRI.

1) Protection from temperature.

2) Protection from wind.

3) Protection from fire.

4) Control of condensation.

5) Admission or exclusion of light.

The coating of these walls, of course, is designed to provide maximum service in terms of both decoration and protection.

In the future, exterior walls will perform all of the present functions, as well as those of heating and cooling the building interior (thermo-electronic systems), and lighting the interior (electroluminescence). They will contain telephone and music systems, and other mechanical and electrical systems, such as fire protection. These will place additional demands upon the materials used in wall structures and the coatings which are used to protect their surfaces. For instance, the "coating" may have to provide structural properties, or the product which serves the structural function may have integral color and surface finish built in, eliminating coatings as we define them today.

However, it is discouraging for me to realize that no radical innovations in types of exterior surfaces will take place in the near future. Slowness to accept new developments appears to be a standard pattern in the construction industry. The curtain wall is an excellent example, since this design concept and prefinishing are closely related. The steel skeleton, upon which curtain wall systems are based, was first utilized in 1883 by William LeBaron Jenney in his Home Insurance Building in Chicago. This created a style of architecture never before possible. The wall no longer had to function as a bearing element, but could serve as a skin: the well known "monotonous" curtain wall. Despite the introduction of this revolutionary concept, for five decades it served only as a prop, supporting classical materials and forms.

There are several reasons for predicting no radical change in the near future:

1) Architects, builders and contractors are hesitant to adopt new materials without historical evidence of adequate performance. Whether the blame for inadequate information and communications should be placed on the architect or the manufacturer is debatable. Nevertheless, this is a serious stumbling block to new product introduction.

2) Building codes and regulatory agencies also hinder rapid acceptance of new products which are not easily compared with conventional materials.

3) Jurisdictional disputes over prefabricated units caused by unions are also factors which tend to slow down new product acceptance.

4) There has been a great tendency to blame external forces for the limitations and problems encountered in this new concept on the part of all who are concerned with prefinished components. We have not been introspective and we have not realized that we have made our own contributions to these shortcomings.

The future of coatings for exterior applications, then, is intimately related to the design and use of wall components. The future does hold bright prospects for new products and developments. However, unless the inertia on the part of those in the construction industry is overcome, these innovations will not reach commercial reality in the next decade or so.

The second part of my presentation will deal with the research needed to overcome this inertia, and in this respect I refer to research in its broadest sense, from the architect on through contractors, component manufacturers, and material suppliers. All of these people must concentrate on and cooperate in research programs which will develop new products, new methods of application, and new techniques in order to take the fullest advantage of our ability to industrialize production.

A quick review of the areas to which these groups can contribute would include:

1) Coatings Manufacturer -- Technical improvements in surfacing.

    a. Better adhesion to wood surfaces.
    b. Greater life expectancy.
    c. Better color retention.
    d. Easier surface preparation.
    e. Vehicle modifications and development, and new synthetic resins.
    f. Blister resistance and mildew resistance.
    g. Greater resistance to chalking.
    h. One-coat paints.

2) Component Manufacturer -- Techniques of fabrication.

    a. Increase use of modular dimensioning and establish more and better standards.
    b. Increase prefinishing of materials and products.
    c. Develop new joining techniques, including use of adhesives.
    d. Reduce cost through increased construction process efficiency.
    e. Improve materials handling methods.
    f. Combine functions of material and equipment.

3) Contractor and Builder -- Techniques of installation.

    a. Improve installation techniques and education of workmen in new developments: better materials handling is necessary if components are to be used.
    b. Reduce the number of skills necessary to complete installations.
    c. Minimize the construction delays caused by adverse weather conditions.
    d. Reduce the length of construction period.
    e. Overcome labor problems related to the use of preassembled components.

4) Architect -- Techniques in design and aesthetics.

    a. Improvements in design functions.
    b. Better utilization of industrialized components.

This research, carried out by both suppliers and component manufacturers, is suffering from a lack of understanding of what a truly prefinished component is. The approach is, for the most part, one of isolating materials rather than designing a true component. The myopic preoccupation with our individual contribution to the component has hindered the efficiency of building design. For example, builders and contractors no longer wish to buy unpainted lumber for siding. Consequently, the manufacturers are required to sell a preprimed product. Of the 10 or 14 distinct operations required to build an exterior wall, this improvement eliminates only one step. Even if the siding is furnished with a finished coating, only two or three steps in the manufacture of the complete wall have been eliminated from on-site handling.

Each component must be conceived with over-all comprehension of the complete house or building, and all of the materials and components, other than the manufacturer's own, with which it is to be used. Future trends will depend on the full cooperation and understanding of all the people involved in the design, utilization and manufacture of exterior components. To date, there has been a less-than-perfect relationship between the architect and the industrial manufacturer.

It is imperative that we create an atmosphere in which each of us will fully understand the needs of the other. Certainly, all of the various groups involved with prefinishing are doing a great deal to overcome the technical problems currently being encountered in the use of prefinished exterior components. However, it is not the technical aspect of prefinished components which has hindered introduction of new products. It is, instead, pressures exerted by regulatory bodies, labor problems, and a natural hesitancy to use an unfamiliar material.

How can we overcome these problems and obtain the maximum benefit of our technological advances in the near future? First, we must develop a cooperative spirit and overcome the self-interest of the parties involved. Research must be carried out which has as its objective the reduction of the excessive time span between product introduction and product acceptance.

1) New and improved test methods on components as a whole, rather than their isolated materials, must be developed. The validity and reliability of these tests must be established so that regulatory agencies and architects can have confidence in the materials which are presented to them and in the manufacturers. It is necessary to guarantee the performance of a component, always remembering that a failure which causes a builder or contractor trouble can be a serious setback, and it would be an almost fatal setback to a fabricator.

2) There must be research which has as its objective the determination of the effects of industrialization on the labor force. Although a great deal of effort is being made to reduce on-site construction time and number of skills required, this is insufficient. All of us are aware of the impact industrialization is having on our labor force at this very minute. Therefore, a program to determine how to best retrain and re-educate the workmen from individual skills to those of the component builder and installer is necessary if we are to overcome resistance to change on the part of the labor force.

The most important area of research, however, is often overlooked or neglected, and that is the one involving communications. Without an adequate program to disseminate news of technological improvements and, by so doing, to know in which direction research efforts are required, all progress is hindered.

All too often we hear architects and contractors complaining about poor communications, lack of standards, and other technical data on the products we want them to use. On the other hand, the architect doesn't want salesmen calling on him perpetually, and with the multitude of products involved in construction, this is justifiable. How else, though, can the manufacturer successfully introduce a new material or technique? Technical data on products are readily available from the manufacturers, but is apparent that the advantages of these materials are not being effectively communicated to the architect.

Effective communication is a two-way street. The architect wants to be active in the development of new materials which he can put to use. This is understandable, since the success of a prefinished component is dependent on its proper utilization by the architect in the design of a building. Yet it appears there is a lack of effective communication between the architect and manufacturer.

Research efforts, then, must include a program designed to develop the quickest and most effective methods to promote closer contact among architects, contractors and manufacturers, and this can only be done in an atmosphere of cooperation and understanding among those involved.

To summarize, briefly, the buildings of the future will be constructed with exterior components performing a much greater variety of functions than they do today. These will require exterior coatings which have different performance standards than at the present time, and they may not even resemble coatings as we now think of them.

These changes will be a gradual evolution because of the multitude of factors which stands in the way of new products -- tradition, regulatory agencies, self-interest, and distrust; that is, unless some effort is made to determine the reasons for these roadblocks, and unless more effective means are found to overcome these obstacles.

Although a great deal of research is being carried out to effect technological improvements in component manufacturing and design, in order to commercialize these applications more rapidly, research should be undertaken to determine methods of retraining workers affected by industrialization; improved methods of testing which will inspire confidence on the part of the architect, client, and regulatory agencies; and, finally, to determine how best to communicate needs and ideas. These things can only be accomplished in a spirit of cooperation, and the self-interest of each element must be eliminated. Only by facing up to these problems and making some serious effort to overcome them will the components of the future become commercial reality.

Previously Published BRI Conference Proceedings

ADHESIVES AND SEALANTS

ADHESIVES IN BUILDING, 1960, 106 pp, illustrated, NAS-NRC Pub. No. 830, $5.00.
ADHESIVES IN BUILDING, Selection and Field Appreciation, Pressure-Sensitive Tapes, 1962, 95 pp, illustrated, NAS-NRC Pub. No. 979, $6.00.
SEALANTS FOR CURTAIN WALLS, 1959, 82 pp, illustrated, NAS-NRC Pub. No. 715, $3.00.
REQUIREMENTS FOR WEATHERPROOFING THIN SHELL CONCRETE ROOFS, 1962, 56 pp, illustrated, NAS-NRC Pub. No. 972, $5.00.

AIR CLEANING AND PURIFICATION

CLEANING AND PURIFICATION OF AIR IN BUILDINGS, 1960, 62 pp, illustrated, NAS-NRC Pub. No. 797, $4.00.

BUILDING RESEARCH, GENERAL

BUILDING RESEARCH; INTERNATIONAL, 1960, 41 pp, illustrated, $1.50.
COLLEGE AND UNIVERSITY RESEARCH REPORTS, 1961, 18 pp, mimeo., $1.50.
DOCUMENTATION OF BUILDING SCIENCE LITERATURE, 1960, 46 pp, illustrated, NAS-NRC Pub. No. 791, $2.00.
NEW BUILDING RESEARCH, FALL 1960, 1961, 86 pp, illustrated, NAS-NRC Pub. No. 910, $6.00.
NEW BUILDING RESEARCH, SPRING 1961, 1962, 170 pp, illustrated, NAS-NRC Pub. No. 986, $10.00.
PROPOSALS FOR NEW BUILDING RESEARCH, 1960, 76 pp, illustrated, NAS-NRC Pub. No. 831, $4.00.

COMPONENT CONSTRUCTION

DEVELOPMENT PROBLEMS WITH COMPONENT CONSTRUCTION, 1961, 22 pp, mimeo., $2.00.
PREASSEMBLED BUILDING COMPONENTS, 1961, 180 pp, illustrated, NAS-NRC Pub. No. 916, $3.00.

DOORS

PUBLIC ENTRANCE DOORS, 1961, 56 pp, illustrated, NAS-NRC Pub. No. 948, $6.00.

FASTENERS

MECHANICAL FASTENERS IN BUILDING, 1959, 26 pp, illustrated, reprint, 25¢.
MECHANICAL FASTENERS FOR INDUSTRIAL CURTAIN WALLS, 1961, 24 pp, NAS-NRC Pub. No. 916, $3.00.

FLOOR-CEILINGS, SERVICE SYSTEMS

FLOOR-CEILINGS AND SERVICE SYSTEMS IN MULTI-STORY BUILDINGS, 1956, 141 pp, illustrated, NAS-NRC Pub. No. 441, $4.00.

FLOORING

INSTALLATION AND MAINTENANCE OF RESILIENT SMOOTH-SURFACE FLOORING, 1959, 145 pp, illustrated, NAS-NRC Pub. No. 597, $5.00.

HEATING

NEW METHODS OF HEATING BUILDINGS, 1960, 138 pp, illustrated, NAS-NRC Pub. No. 760, $5.00.

ILLUMINATION

BUILDING ILLUMINATION: The Effect of New Lighting Levels, 1959, 160 pp, illustrated, NAS-NRC Pub. No. 744, $5.00.

MASONRY

MODERN MASONRY: Natural Stone and Clay Products, 1956, 164 pp, illustrated, NAS-NRC Pub. No. 466, $4.50.

INSULATED MASONRY CAVITY WALLS, 1960, 82 pp, illustrated, NAS-NRC Pub. No. 793, $4.00.

METAL CURTAIN WALLS

DESIGN POTENTIAL OF METAL CURTAIN WALLS, 1960, 84 pp, illustrated, NAS-NRC Pub. No. 788, $5.00.

METAL CURTAIN WALLS, 1955, 190 pp, illustrated, NAS-NRC Pub. No. 378, $4.00.

MODULAR COORDINATION

CURRENT STATUS OF MODULAR COORDINATION, 1960, 30 pp, illustrated, NAS-NRC Pub. No. 782, $2.50.

NOISE CONTROL

NOISE CONTROL IN BUILDINGS, 1959, 150 pp, illustrated, NAS-NRC Pub. No. 706, $5.00.

NUCLEAR DESIGN

DESIGN FOR THE NUCLEAR AGE, 1962, 162 pp, illustrated, NAS-NRC Pub. No. 992, $10.00.

OPERATION AND MAINTENANCE

PERFORMANCE OF BUILDINGS, 1961, 94 pp, illustrated, NAS-NRC Pub. No. 879, $5.00.

WORKSHOP ON WINDOWS, 1959, 22 pp, reprint, 25c

PAINTS AND COATINGS

FIELD APPLIED PAINTS AND COATINGS, 1959, 150 pp, illustrated, NAS-NRC Pub. No. 653, $5.00.

PAINTS AND COATINGS: Field Surface Preparation, Field Application Methods, Water Thinned Materials, 1960, 72 pp, illustrated, NAS-NRC Pub. No. 796, $5.00.

PLASTICS

PLASTICS IN BUILDING, 1955, 150 pp, illustrated, NAS-NRC Pub. No. 377, $5.00.

PLASTICS IN BUILDING ILLUMINATION, 1958, 100 pp, illustrated, $3.00.

PLASTICS FOR ROOF CONSTRUCTION, 1957, 125 pp, illustrated, $3.00.

INFORMATION REQUIREMENTS FOR SELECTION OF PLASTICS FOR USE IN BUILDING, 1960, 40 pp, illustrated, NAS-NRC Pub. No. 833, $3.00.

INTERSOCIETY REPORTS ON PLASTICS IN BUILDING ACTIVITIES, 1962, 68 pp, NAS-NRC Pub. No. 978, $5.00.

ROOFING

A STUDY TO IMPROVE BITUMINOUS BUILT-UP ROOFS, 1960, 33 pp, BRI Mono. No. 1, $1.50.

REQUIREMENTS FOR WEATHERPROOFING THIN SHELL CONCRETE ROOFS, 1962, 47 pp, illustrated, NAS-NRC Pub. No. 972, $5.00.

SANDWICH PANELS

SANDWICH PANEL DESIGN CRITERIA, 1960, 228 pp, illustrated, NAS-NRC Pub. No. 798, $8.00.

SPECIFICATIONS

SPECIFICATIONS WORKSHOP, 1957, 28 pp, $2.00.

STRUCTURAL FOAMS

STRUCTURAL FOAMS, 1961, 83 pp, illustrated, NAS-NRC Pub. No. 892, $5.00.

WINDOWS

WINDOWS AND GLASS IN THE EXTERIOR OF BUILDINGS, 1957, 176 pp, illustrated, NAS-NRC Pub. No. 487, $5.00.

WORKSHOP ON WINDOWS, 1959, 22 pp, reprint, 25¢.

Order these publications from Publishing Office, National Academy of Sciences, 2101 Constitution Avenue, Washington 25, D.C. A full list of BRI publications is available on request.

BUILDING RESEARCH INSTITUTE

The Building Research Institue is a unit of the Division of Engineering and Industrial Research of the National Academy of Sciences -- National Research Council. BRI was organized in 1952 to meet the need of building scientists for an organization which would be concerned with the whole of building research and technology. It also acts as an information center and maintains liaison with building research agencies in other countries throughout the world.

The members of BRI are people interested in advancement of the science of building. Among those listed as BRI members are: architects, engineers, contractors, home builders, building owners, manufacturers of building products and materials, distributors, technical and professional societies, trade associations, research laboratories, financial, real estate and insurance firms, trade and consumer publications, professional consultants and technical experts from colleges, universities and government agencies in this country and abroad. Memberships are open to companies, associations, societies and individuals.

MEETINGS

Operating on the principle that the personal exchange of experience and ideas is the basis of the growth of a science, BRI conducts:

1) Research correlation conferences on specific building problems and cross-industry consideration of experience in the application of new building products and methods of construction (Open to the public).

2) Committee, workshop and round-table activities in which members and guests participate by invitation.

BRI research correlation conferences are held twice a year, spring and fall. At these conferences, programs on various subjects of interest to the building industry and its related professions of architecture and engineering and presented in half-day, full-day, two-day or three-day sessions, depending on the field to be covered and the amount of time necessary.

PUBLICATIONS

The Building Research Institute publishes and distributes to members the proceedings of its conferences, technical meetings and study groups. Building Science News, the Institute newsletter, reports monthly on Institute activities, as well as on building research news of general interest, and incorporates a two-page monthly digest of new articles and reports on building research. Building Science Directory, founded in 1956, provides a comprehensive guide to sources of information on research and technical developments in the industry. Supplements to the Directory are issued annually with an index. All of these services are provided to BRI members without charge. Nonmembers may purchase copies of published proceedings of public conferences and regular issues of the Building Science Directory at nominal cost.

NATIONAL ACADEMY OF SCIENCES— NATIONAL RESEARCH COUNCIL

The National Academy of Sciences–National Research Council is a private, nonprofit organization of scientists, dedicated to the furtherance of science and to its use for the general welfare.

The Academy itself was established in 1863 under a Congressional charter signed by President Lincoln. Empowered to provide for all activities appropriate to academies of science, it was also required by its charter to act as an adviser to the Federal Government in scientific matters. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a governmental agency.

The National Research Council was established by the Academy in 1916, at the request of President Wilson, to enable scientists generally to associate their efforts with those of the limited membership of the Academy in service to the nation, to society, and to science at home and abroad. Members of the National Research Council receive their appointments from the President of the Academy. They include representatives nominated by the major scientific and technical societies, representatives of the Federal Government, and a number of members-at-large. In addition, several thousand scientists and engineers take part in the activities of the Research Council through membership on its various boards and committees.

Receiving funds from both public and private sources, by contributions, grant, or contract, the Academy and its Research Council thus work to stimulate research and its applications, to survey the broad possibilities of science, to promote effective utilization of the scientific and technical resources of the country, to serve the Government, and to further the general interests of science.